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AN INTERESTING PRODUCER-GAS PLANT.*

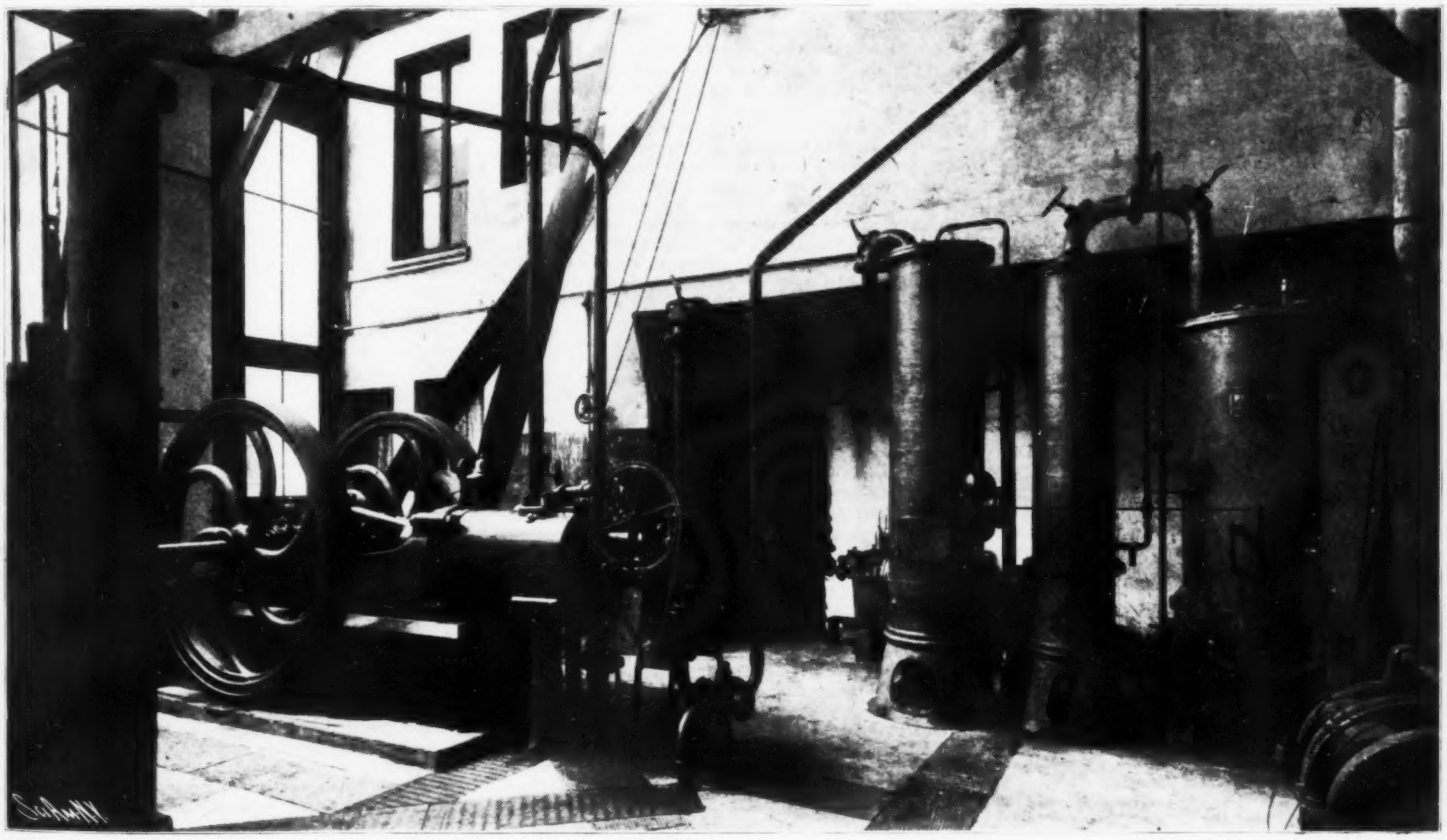
By Emile Guarini.

During a recent trip to Paris, I visited the gas-generating installation of Messrs. Maystre & Ledoyen, at Puteaux (Seine). The accompanying photograph shows a good view of this plant, which, according to the house, is giving full satisfaction. The apparatus which was installed by Messrs. Pierson & Co., Paris, consists of a 23-horse-power Crossley low-grade gas engine running at 180 R. P. M., and a Pierson suction gas producer of 23 horse-power capacity, working perfectly with poor-quality coal. A special feature of this generator is that it operates with an open furnace. The apparatus consists of a boiler and a cylinder lined with refractory material and containing the fuel. The fire is easily made by means of a vertical rod, which is capable of piercing the crust of clinkers without deranging the fire. There is no grate, and the fuel rests upon a bank of cinders that forms upon a refractory hearth. Thus not only are entrances of air prevented, but the cleaning can be done without haste, and the passages be kept constantly unobstructed. When the plant is run only in the daytime, it is charged but once, before starting the motor. What is particularly interesting in this new generator is that there is a methodical and automatic regulation of the volume of the steam aspired, according to the fluctuations in the work of the motor, the aspiration always remaining the same. When running under a full load, the maximum amount of steam is allowed to enter, in order to prevent too great an elevation of the temperature of the furnace. Here the volume of water entering for vaporization is not acted upon, since it is too small to admit of a proper regulation, and therefore the admission of the steam is regulated.

Aside from the producer proper, the installation naturally comprises a condenser, a coke column with methodical washing, and a drying purifier. The gas coming from the generator enters the condenser, which consists of a cylinder surrounded with a double water-jacket. In this the cooled gas deposits a portion of its tar, and the coal dust falls into the base of the apparatus, whence it can be easily removed. The gas afterward passes into the coke column, and enters the purifier previous to being aspired by the motor. The gas-supply pipe of the motor that runs from this coke column has connected to it, through a short branch, a cylindrical chamber, and in the connecting branch is arranged a valve that opens under the effect of the motor's suction, and closes again by its own weight. Upon one side of the cylindrical chamber there is a diaphragm, which through a rod and lever actuates a steam valve. A small cock with graduated sector, and which can be set once for all at the time of regulating the apparatus, permits of counterbalancing the vacuum in the cylindrical chamber according to the speed of the external air that is aspired at the moment at which a suction of the motor brings about a depression. This same depression is established at the column, the diaphragm is drawn toward the interior of the cylinder, and, opening the steam valve, permits the steam to pass from the boiler to the cylinder, and to be aspirated at the same time as the air under the furnace. The steam valve therefore permits of the passage of more or less steam, according to the extent of the vacuum in the column. This vacuum, moreover, is rapidly filled with air entering through the small cock. Thus the motor, through a special conduit, sucks gas through the first of the suction devices, and this suction corresponds to the introduction of a certain quantity of air and steam into the furnace. This brings about in the incandescent fuel the characteristic actions $O + C = CO$ and $H_2O + C = 2H + CO$, which give the combustible gases that are to be ignited in the cylinder of the motor.

We here have a mechanical solution of the problem, and one that has the advantage of giving an absolute stability to the quality of the gas produced, and a regular operation of the motor supplied.

* Specially prepared for the Scientific American Supplement.



THE MAYSTRE-LEDOYEN PRODUCER-GAS PLANT.

MOTOR BOATS IN WARFARE.

A newspaper states that the British Admiralty has accepted Mr. S. F. Edge's offer of two of his Napier motor boats for use during the forthcoming naval and military maneuvers. Mr. Edge, in talking to a reporter of the Midland Gazette and Express, claimed that his motor boats can easily travel 1,000 miles with an average speed of 22 miles an hour; and, enormous as this radius of action is, he believes that a person will have to live only to a reasonable old age to be able not only to cross the English Channel, as he does now, by a motor boat, but the Atlantic as well.

"As to the use of the motor boat in naval warfare," Mr. Edge says, "the possibilities are enormous and the advantages supreme. Owing to the speed at which it travels—25 miles an hour can be kept up even now, which is the beginning of marine motoring—it is next to impossible to hit a motor boat with a big gun. The smoke from an enemy's gun, after a shot has been fired, can be seen, and in the interval before the projectile can reach the boat there would be time to stop it or to alter its course. The lightness of the boat and the consequent absence of momentum allows it to stop practically when the engine is stopped.

"In motion the boat is almost invisible. It lies down in the trough of the waves, or in the track cut by itself as it progresses. Herein lies its great advantage for scouting or going out to view the enemy, who can be seen without the knowledge that they have been watched. This is the point I wish to prove by lending my motor boats to the Admiralty. If they accept I shall go out in one myself.

"The motor boats offer the only means so far devised of attacking an enemy's submarines. Behind a motor boat a torpedo can be trailed, the submarine outside a port sighted and exploded, and a rapid return made without giving the enemy a chance of retaliation. A motor boat, moreover, is practically immune from attack by a torpedo."

Mr. Edge's motor boats have been constructed to carry from three to twelve persons, and not one is over 40 feet in length.

There is, however, another side of the motor-boat question. At the request of the editor of the Autocar, Mr. Fred T. Jane, author of "All the World's Fighting Ships," and an able critic of naval matters, wrote an article on "Motor Boats for Naval Purposes." He was no doubt selected because he is an enthusiastic automobilist, yet, as the following outline of his argument shows, he can offer no encouragement to the builder of the gasoline internal combustion engine:

"First and foremost, petrol (gasoline) is not considered a suitable thing to carry on shipboard, the dangers from fire being too great for it to be used on

large ships. However safe a few cans of 'motor spirit' may be, transference from a ship to a boat would have to be by hose and makeshift methods, entailing 'mixture' round the ship. A motor boat which cannot be fed from a ship is useless, because its radius is too small. Petrol is undeniably dangerous in submarines. With them it is used only from absolute necessity. The authorities will not unbend in this matter. Even ordinary liquid fuel—heavy petroleum—has had setbacks from the ease with which it is accidentally fired, and nothing but its conspicuous advantages in assisting speed would have admitted it on shipboard at all. It will take more than the runs of a sportsman to convince the naval world that the motor boat is an excellent substitute for the ordinary steam launch, but there is probably a great deal more money in developing steam. The steam launch is probably more suited for naval uses than the petrol boat. Little as we see of the steam car on the road it is still a thing of possibilities.

"The steam motor boat, though not in evidence or boomed like the petrol boat, is very probably the coming craft. On the water it will be but the development of existing means of locomotion. The present steam cutter or picket boats, running for perhaps six hours at 15 knots speed or less, are not ideal, have not sufficient radius, have minor breakdowns, yet tow other boats, do a lot of work, stand being hoisted in and out frequently in choppy seas, are let down rather heavily now and then on to their places on board without things coming loose, are badly strained in all sorts of ways, are continually tinkered in dockyards and looked after on shipboard by men who have to do double shifts at odd times when they can be spared. It begins to strike one that the motor boat, as we know it, has a good deal to do and a good way to go before it will do the work better. To be a racer one day and a haul-about the next is no light task.

"The present types of carbureters will never deliver petrol properly in a heavy seaway. If a motor car be on a tilt there may be bother, and there are motor cars which fail on hills because the carbureter does not act beyond a certain angle. In a seaway in a motor boat it would be both all the time. The spray which will function properly under those conditions will be a very complicated concern indeed, for it will have to stand the equivalent of what for a shore-going car would be tumbling into a ditch some twelve times a minute. Electricity is, of course, out of court, because accumulators weigh too much. Paraffin and alcohol mean more complication, and complication is out of favor in high places at present.

"Next, the shape of the boats which have lately disported themselves in the Solent is all wrong, except the Georges-Richard. The wave thrown up by the average boats renders them totally useless for war work. When torpedo craft attack at night it is almost always the white bow wave which gives them away to the watchful lookouts. The Frenchman alone seems to have had an inkling of that, supposing war work to have been in the minds of any of the Solent racers. Very possibly, of course, it was not; but whether it was or not, no boat with a big wave has a ghost of a chance of being of utility in war.

"One virtue of the motor boat is supposed to lie in its silence, but silence is a moderate virtue. The ordinary destroyer or torpedo boat makes a good deal of noise, but it is rare, indeed, for one to have been detected on that account. There are so many noises on board a big ship—engines, auxiliary engines, dynamos, and so on—that a little extra noise in the far away is little likely to attract attention. Silence, therefore, is alone not likely to bring in the motor boat.

"Finally, the naval mind, taught by long experience, is conservative, and the motor boat to be adopted must possess a very marked superiority over the ordinary steam one to stand any chance of adoption.

"A word may be added about the proposal of some enthusiast that motor-boat volunteers should be raised for coast defense purposes, their boats being provided with torpedoes. Such a proposal is absolutely ridiculous and very dangerous to boot. Unless the British navy is hopelessly defeated coast defense will be little required; but the main danger lies in the fact that such boats, if they did succeed in torpedoing anything, would most probably sink our own ships. The torpedo is emphatically only a weapon to intrust to skilled regulars."

Perhaps I may be permitted to suggest—a point which Mr. Edge and Mr. Jane do not touch upon—that "skilled regulars" of an army might use a mosquito fleet of motor boats to protect seacoast towns and harbors, and with our extensive seacoasts might be invaluable as well as, comparatively speaking, inexpensive. The storage of gasoline on land and its transference to the motor boat need not be dangerous, as in the case of ships.

Since preparing the foregoing I find that there is some discrepancy in the account of the reception the Edge offer has had. One paper states that Mr. Edge offered the boats to the War Office and to the Admiralty; that the former accepted promptly and that the latter had not yet decided.—Marshal Halstead.

The rebuilding of Baltimore, says Engineering Record, is taking place rapidly, although but a year has passed since the disastrous fire which swept over 155¼ acres of the city and destroyed 1,382 buildings. The clearing of the wreckage is almost completed, and 377 buildings are either finished or under construction in the burned district. Part of the burned territory has been appropriated by the city, leaving 958 lots for private buildings. The 377 new buildings cover lots on which there were 501 buildings before the fire, and their total declared valuation is more than $84,000 over the assessments for taxation on the 958 buildings which were destroyed.

INCANDESCENT LIGHTING BY MEANS OF ACETYLENE AND THE CARBURIZATION OF ACETYLENE.*

It is practically rather difficult to obtain the exact mixture of air and of gas, that is to say, to give to the apertures for the escape of acetylene and admittance of air exact reciprocal dimensions; for the differences, though slight, in the size of the apertures, which cannot be avoided in manufacture, exert a considerable influence on the function of the burner.

Burners in trade are subject to this defect in a very high degree; of burners coming from the same factory, some act perfectly well, the mantle being traversed under a pressure of 40 to 50 millimeters, while other burners can only be employed under a pressure exceeding 110 millimeters. This difficulty encountered in incandescent burners for acetylene constitutes a serious obstacle to their adoption.

Another inconvenience arises from the construction of the burners. As I have already remarked, the proper action of the burners depends on obtaining in a tube of suitable diameter a determinate mixture of air and gas, which will not explode in the tube.

In order to secure this mixture, the acetylene must escape from the aperture under a certain pressure, that is to say, with a certain speed. It is evident that the relative speed is only produced when the burner is lighted, that is to say, when the hot gases form a certain continuous current, and thus attain a normal speed. When this result has not been attained, as, for instance, at the moment of lighting, a mixture of air and gas is formed, which is explosive in consequence of the size of the opening of the burner, the gas exploding at that moment.

The same thing occurs at the moment of extinction, the shutting off of the gas producing a perturbation in the composition, and forming an explosive mixture.

The detonation which takes place at the times of lighting and extinguishing, and which it is difficult to avoid, exerts a very unfavorable influence. These slight explosions cause a shaking of the mantle, which impairs its solidity, and in the mixing chamber small quantities of soot and tar are deposited, which frequently produce an obstruction of the apertures.

Another trouble with burners at present employed for incandescent lighting with acetylene lies in the necessity, caused by the construction of the burner, of suspending the incandescent bodies laterally. On account of this suspension metallic supports are required, which are easily bent under the action of heat, and in this way cause a deterioration of the incandescent bodies. This is the more to be regretted, as it is apparently inseparable from the system of the burners and therefore inevitable.

I am convinced that sooner or later a system will be devised exempt from these inconveniences, which will be welcomed with the liveliest satisfaction; for incandescent lighting with acetylene constitutes an extremely important factor for the development of the acetylene industry.

The experiments made with incandescent acetylene burners have demonstrated that present systems have already given excellent results. As can be seen, the average product is three and a half candles per liter and per hour under a pressure of 100 millimeters; besides, experiments in duration have demonstrated that the intensity in incandescent lighting abates but little in time.

The maximum of lighting power is not obtained at the outset, but after a combustion of about twenty hours. The reason for this is that the present incandescent mantles are not shaped in accordance with the flame; only while burning are they dilated, and thus develop the maximum of intensity.

ADVANTAGES OF PURIFIED ACETYLENE.

The experiments in duration have likewise demonstrated the considerable value of the proper purification of acetylene.

When it is not purified, or when it is imperfectly purified, spots are formed on the surface of the incandescent bodies after a short time, sometimes in two or three hours, which are soon converted into holes. The impurities, especially phosphorus, form with the matter of the incandescent bodies easily fusible compounds, causing an immediate deterioration of the incandescent bodies. With well-purified acetylene this does not happen, and the incandescent bodies are maintained in a perfect state of preservation.

The economical value of incandescent lighting with acetylene is indicated in Tables I. and II., which show by comparison the cost of a burner of 30 candle power. These have been arranged after the well-known plan of Herzfeld and Fröhlich, the present price of carbide having been taken into account, and that of all the other lighting agents, such as water gas, aerified gas, the Nernst lamp, etc.

It can be seen from the comparative table that incandescent lighting with acetylene holds the first place among lighting agents. It has at the same expense the advantage of incandescent lighting with carburized water gas, compressed water gas, and simple water gas, and of being economically consumed in a burner of small size, as for instance, a burner of eight liters, which gives an excellent diffusion of light.

Considering that for all the modes of incandescent lighting, the expense of mantles, glasses, etc., is the same, this has not been taken account of here.

Incandescent lighting with acetylene has not uttered its last word. Independently of the fact that a large consumption allows of obtaining more than five candle-power per liter, it is evident, in regard to lighting with acetylene, that under the same tests as coal-gas, excellent results will surely be attained.

The modern incandescent lighting with gas rests on the principle, that in the flame of the non-lighting gas a solid body is introduced, which is brought to incandescence by the heat of the flame, and emits in this state luminous rays. These rays are due first of all to the very nature of this body, as well as to the heat which the flame disengages. The heat is produced by the natural temperature of the gas-flame, increased artificially by the addition of substances which stimulate the combustion of gas on the surface. Cerium oxide is generally employed for this purpose.

TABLE I.

Cost of Original Materials in Francs and Centimes.

1 cubic meter of lighting gas ....about	0.19
1 liter of petroleum	0.25
1 liter of alcohol..............................	0.45
1 kilogramme of benzine......................	0.38
1 kilogramme of carbide (180 to 300 liters)......	0.25
1 cubic meter of acetylene......................	1.0
1 cubic meter of acetylene (municipal works)..	1.85
1 cubic meter of oil-gas and acetylene (in proportion of 1 to 3)........................	0.50
1 cubic meter of oil-gas and compressed acetylene	0.82
1 cubic meter of oil-gas........................	0.35
1 cubic meter of compressed oil-gas	0.50
1 cubic meter of water-gas	0.12
1 kilowatt-hour	0.80
1 cubic meter of water	0.20
1 cubic meter of aerified gas	0.58
1 cubic meter of carburized acetylene	0.95

TABLE II.

Mode of lighting.	Consumption per candle and per hour.	Cost per 30 candles in centimes.
Incandescent lighting with acetylene	0.30 liter	about 0.90
Incandescence with carburized water-gas	2.00	0.90
Compressed water-gas ...	1.0l. + 0.50 water	0.90
Incandescent lighting with water-gas	2.50 l.	0.93
Incandescent lighting with oil-gas	1.00	0.93
Incandescent lighting with petroleum..........	0.00125 gr.	0.95
Incandescent lighting with carburized acetylene ..	0.35 l.	0.96 to 0.97
Incandes't lighting with gas	2.00	1.12
Incandescent lighting with aerified gas	0.77	1.3
Incandescent lighting with acetylene (munic. w.) ..	0.30	1.68
Mixed gas (acet. and oil-gas)	1.30	1.82
Acetylene	0.75	2.25
Petroleum	0.00359 gr.	2.7
Arc lamp	1.1 watts	2.72
Oil-gas	3.20 l	3.36
Acetylene (municipal wks.)	0.75	4.20
Nernst lamp	2 watts	4.50
Acetylene and compressed oil-gas	1.80 l.	4.76
Carburized water-gas	15.00	5.62
Lighting gas (round burner)	10.00	5.62
Lighting gas (butterfly bnr)	11.5	6.45
Compressed oil-gas	4.55	6.82
Elec. light by incandescence	3.1 watts	7.03

The temperature of the acetylene light is very high. The ordinary light has a temperature of 1,650 deg. C. (table III.); a mixture of 7.4 per cent of acetylene and air has a temperature of 2,420 deg.; a mixture of 12.9 per cent of acetylene and air, 2,260 deg.; and a mixture of 17.37 per cent of acetylene and air, 2,100 deg.

TABLE III.

Giving in Centigrade Degrees Various Temperatures of Light.

Acetylene	1650
74 p. c. of C_2H_2	2420
12.9 p. c.	2260
19.37 p. c.	2100
Burner of the General Comp. A.C.A.G. (10 p. c.)	1630
Burner Hera-Prometheus (12 p. c.)............	1720
Güntner burner	1860
Serius burner	1630

In regard to the temperature of the natural flame, it is in favor of acetylene, but it is not yet definitely determined how this temperature is artificially increased by the combustion of the incandescent bodies. However, several experiments have demonstrated to my satisfaction that the mixtures of oxides usually employed for the preparation of mantles designed for incandescent lighting with gas (about 97 per cent of thorium oxide with 1 per cent of cerium oxide) do not give the best results with acetylene, and that it would be desirable to add some other oxides.

As I have stated, the question of incandescent lighting with acetylene has not yet been settled definitely. However, I obtained, under a pressure of 110 millime-

* Condensed from the French of Dr. N. Caro, in the Revue Generale de Chimie Pure et Appliquée.

ters 1.50 candles per liter and per hour, and I do not consider that this constitutes the maximum output, and that five candles per liter and per hour may be produced.

CARBURIZED ACETYLENE.

As a continuation of the subject of incandescent lighting with acetylene, I will describe a new application of the greatest importance, as it renders possible the mastery of the serious difficulties which still constitute an obstacle to the development of the acetylene industry.

I refer to carburized acetylene. According to a process patented by Heil, of Frankfort on the Main, the acetylene, before use, is saturated with the vapors of petroleum, benzine, benzene, alcohol, etc.

It must be remarked that my experiments have been conducted with gas obtained by the carburization of acetylene by means of benzine, and that my views are based on the employment of this gas.

The treatment of acetylene in a carbureter of simple construction furnishes, according to the degree of pressure, gaseous mixtures of the following composition:

1. One hundred liters of acetylene, absorbing on an average 125 grammes of benzine, produce 150 liters of gaseous mixture.

2. One hundred liters of acetylene, absorbing on an average 250 grammes of benzine, produce 200 liters of gaseous mixture.

Gas No. 1 is composed of 66.6 per cent of acetylene and 33.4 per cent of benzine vapor; gas No. 2 is composed of 50 per cent of acetylene and 50 per cent of benzine vapor. With these gases a series of experiments were undertaken, of which the following are the results:

1. The limits of the explosion of these gases were first determined according to the method proposed by Kubierschky for explosive mixtures, and values found as given in Table IV. Carburized acetylene appears by the experiments as more desirable than other modes of lighting by explosive gaseous mixtures.

2. The heating power of carburized acetylene has been determined by means of the Junker calorimeter as 16,610 calories for gas No. 1 and 18,640 calories for gas No. 2.

TABLE IV.

Limit of Explosion of Various Gaseous Mixtures.

Nature of mixtures.	Lowest.	Highest.
Benzene	1.4	4.7
Alcohol	4.0	?
Methylic alcohol	7.8	(18.0)
Ethylic ether	1.8	5.2
Hydrogen	9.5	64.7
Carbon oxide	14.3	74.6
Methane	6.0	13.0
Lighting gas	8.0	19.0
Benzine	2.6	4.6
Acetylene	2.8	66.2
Water-gas	12.5	66.5
Carburized air	4.8	10.1
Carburized acetylene I	5.4	10.2
Carburized acetylene II	4.8	9.2

TABLE V.

Calorific Power of Various Gases and Vapors per Cubic Meter in Calories for Comparison.

Gasogen gas	950
Water gas	3,020
Hydrogen	3,080
Lighting gas	5,000
Carburized air	12,000
Acetylene	14,000
Carburized acetylene	19,000

As can be seen, carburized acetylene possesses a heat of combustion equal to three times and a half that of lighting gas, and 30 per cent superior to that of acetylene.

3. The temperature of ignition of carburized acetylene No. 2 has been estimated at 582 deg. C.; the temperature of ignition of acetylene is 480 deg. and that of lighting gas about 600 deg.

4. It has not been possible to determine exactly the rapidity of ignition of a mixture of carburized acetylene and air; this rapidity has been estimated by observing it in a tube about ten meters in length. This speed requires approximately, with a mixture of 8 per cent carburized acetylene No. 2 and 92 per cent of air, 3.8 meters per second; that is to say, this speed equals three-quarters of the speed of pure acetylene, determined by Prof. Le Chatelier as being 0.18 meter per second for a mixture of 2.9 per cent of gas and air, 5 meters for a mixture of 8 per cent of acetylene and air, and 10 meters for a mixture of 10 per cent of acetylene and air.

5. The temperature of an ordinary carburized acetylene flame No. 2 has been estimated at 1,600 deg. C., and that of a non-illuminating flame in the Bunsen burner at 1,650 deg. However, it must be remarked that the quantity of air employed in this case has not been measured.

6. The measurement of lighting power of the carburized acetylene flame gives per candle-hour a flow of 0.80 liter to 1 liter in a simple burner of 10 liters, and a flow of 0.34 liter to 0.36 liter, in an incandescent burner.

7. Protracted experiments have been made for determining the manner in which carburized acetylene behaves while cooling. These experiments had really a double purpose; first, to ascertain the quantity of benzine vapor separated on cooling, and afterward the nature of the resultant gas; that is, the photometric and calorific properties which the cooled gas possesses.

The experiments were effected in the following manner: The acetylene issuing from a generator was made to pass through a purifying apparatus, then through a first test counter, a carbureter, a second test counter, and a condenser. This last apparatus was composed of a glass serpentine of about twenty coils placed in a condensing vessel. The lower extremity of the serpentine opened into a bellied tube for condensation having double tubulure placed in an open glass and cooled at the same temperature. The benzine which became separated was deposited in this glass, while the gas was drawn to the burner of the calorimeter.

The first counter indicated the liters of acetylene consumed, and the second counter the liters of gaseous mixtures, the difference in the weight of the carbureter, the grammes of benzine employed, the difference in the weight of the condensing tube, the grammes of benzine separated. The volume of the gas obtained after separation from benzine was calculated according to the quantity of benzine separated. The speed of the gaseous current was from fifteen to twenty liters per hour under a pressure of 100 millimeters. The condenser was not employed after the first experiment. An average of six tests gave the following results:

a. The acetylene employed yielded per liter 12,962 calories; in a burner with an open flame and a flow of 10 liters, 1.33 candles, and in the incandescent burner, 3.72 candles per liter per hour.

b. Ten liters of acetylene absorbed at 20 deg. C. 26.55 grammes of benzine, having a specific weight of 0.6724, and gave 21.6 liters of gaseous mixture. This gaseous mixture yielded with the incandescent burner 3 candles, with the burner of 10 liters with an open flame 1 candle per liter and per hour, and in the calorimeter 10,236 calories per liter.

c. Twelve liters of this gas were refrigerated at zero, which caused a separation of 6.81 grammes of benzine, corresponding to 46.6 per cent.

The gas gave after cooling, per liter of gas originally employed 13,400 calories, which, taking into account the diminution of volume, amounts to 7,866 calories for a liter of refrigerated gas.

The photometric measuring of the refrigerated gas gave in the burner with the open flame 1.11 candles, and in the incandescent burner 3.10 candles per liter and per hour.

d. Thirteen and three-tenths liters of this gas were cooled to 12 deg. C. below zero; the quantity of benzine separated amounted to 13.7 grammes, which corresponds to 83.32 per cent. The gas gave for each liter employed originally 9,070, which corresponds to 16,436 calories per liter of refrigerated gas, for the volume of the latter was estimated at 7.35 liters. The photometric effect of the gas obtained after cooling equaled in the open flame burner 1.21 candles, and in the incandescent burner 3.16 candles, per liter and per hour.

These experiments demonstrate that an appreciable separation of the absorbed benzine results from the cooling of the carburized acetylene. However, the gas obtained after cooling exhibited, with respect to its calorimetric effect, not a lessening, but on the contrary a photometric improvement.

Afterward, researches were made as to the manner in which carburized acetylene would behave at a low temperature. For this purpose the carbureter was surrounded with melting ice, and the following results were obtained: 10 liters of acetylene absorbed 12.1 grammes of benzine, and then produced 15.3 liters of gaseous mixture; the gas obtained, which was then composed of 6.49 liters of acetylene and 7.85 grammes of benzine, gave in the calorimeter 15,789 calories per liter. The carburization at zero yields, therefore, a gas containing less benzine than a carburized gas at an elevated temperature and afterward cooled.

The lowering of the temperature of carburization causes a diminution of the calorimetric effect. As it is known that the separation of the benzine absorbed and the depreciation of the quality of the gas which takes place in consequence of it, in the thermic as well as photometric respect, constitute the principal defect of carburized air, it appeared to me desirable to compare the last mentioned gas with carburized acetylene. Experiments on carburized air have been made identical with those on acetylene, with this difference, that instead of acetylene, it was air which was accumulated in the gasometer and sent into the carbureter under a pressure of 100 millimeters. On an average the following results were obtained:

a. Ten liters of air absorbed at 20 deg. C. 24.1 grammes of benzine and produced 20 liters of carburized air. This gas yielded 12,730 calories, which gave in the open flame burner 0.128 candle, and in the incandescent burner 1.3 candles per liter and per hour.

I present a few figures:

b. Twenty-three and three-tenths liters of this gas were cooled at zero and separated 11.4 grammes of benzine, or 40.4 per cent. The gas obtained after cooling gave 9,140 calories per liter and per hour, or 0.5 candle in the incandescent burner and 1 candle in the open flame burner.

c. By cooling at 12 deg. below zero 20 liters of this carburized gas, it separated 16.2 grammes of benzine, or 67 per cent; the gas obtained gave in the Junker calorimeter 5,180 calories per liter and per hour, or 0.24 candle in the incandescent burner, and in the open flame burner 0.06 per liter and per hour.

Practically, carburized air seldom yields more than 6 calories, and under this condition the above mentioned figures would require considerable modification, which would not be in favor of carburized air.

According to these experiments, the separation of benzine seems to be greater with carburized acetylene than with carburized air. However, this result is only obtained when, on cooling, the pipe is placed vertically, so that the products of condensation can escape, and the pipe and the vessel for condensation are subjected to a uniform refrigeration. If, however, the experiments are made in a manner more in accord with the usual practice, by simply cooling a part of the horizontal pipe, so that the products of condensation which might have accumulated, can serve again for the carburization, other figures are obtained.

Gas composed of 58.3 per cent of acetylene and 41.7 per cent of benzine vapor abandons while cooling at 10 deg. C., 6.0 per cent; at 8 deg., 7.6 per cent; at 5 deg., 9.2 per cent; at 3 deg., 16.8 per cent; and at zero, 24.3 per cent of benzine.

Carburized air containing 43.6 per cent of the same benzine vapor abandons while cooling at 10 deg. C., 18.6 per cent; at zero, 76.9 per cent of the benzine which it contained.

It would consequently seem as though friction acted an important part in decarburization, which has also been demonstrated by a second experiment.

8. It has been ascertained that the composition of carburized acetylene is only slightly changed in consequence of the friction against the walls of the conduit; during a course of 25 meters through a pipe a quarter of an inch in diameter and under a pressure of 60 millimeters the separation amounted only to 0.62 per cent. The separation with the carburized air was 5.85 per cent.

It has been demonstrated that the most prominent properties of carburized acetylene consist in its slight explosive power and in its great heat of combustion; these two qualities exhibit well the advantage which may be gained by utilizing this gas for incandescent lighting, heating and for motive power.

Employed for incandescent lighting, it presents over pure acetylene the advantage of the absolute impossibility of the flame being turned back. Not only ordinary incandescent burners may be used, admitting air abundantly, but the flame may be lowered completely, assuring combustion under low or high pressure, and avoiding all explosion or detonation, as well on lighting as on extinguishment, or on diminishing the pressure. As, in consequence of the elevated temperature of combustion, the photometric effect is excellent, the employment of carburized acetylene presents in regard to convenience an immense advantage over the ordinary incandescent acetylene light. The extraordinarily low explosive force of carburized acetylene makes it possible to employ this gas in small as well as in large burners, even in those which are in present use for coal-gas.

The low explosive force of carburized acetylene presents considerable advantage in the use of this gas for heating.

CARBURIZED ACETYLENE EMPLOYED FOR HEATING AND FOR MOTIVE FORCE.

Ordinary coal-gas stoves which give a blue flame may be employed without undergoing much modification. The flame may be turned down as low as it appears desirable in an apparatus of this kind. The detonation produced with acetylene stoves and the cloud of soot which is dreaded are done away with. The great calorific power of carburized acetylene must also be taken into account (which is 30 per cent greater than that of ordinary acetylene) and the elevated temperature possessed by its flame.

Carburized acetylene is especially fitted for being employed for motive power; it is well known that a gas employed for this purpose ought to have the desired qualities with reference to its temperature of ignition, heat of combustion and rapidity of explosion.

Gases possessing these qualities are certainly the most appropriate for being utilized in gas-motors for the following reasons:

The yield of a motor is the greater, the higher the degree of compression to which the mixture of gas and air is subjected before lighting. In the working of a motor, the compression can only be pushed to a certain limit, for the compression originates heat, and gases capable of ignition at a low temperature are ignited before the desired degree of compression is attained. The higher the ignition temperature, the greater the compressibility, and the more effective the motive power.

Of course, the heat of combustion increases the force of a motor operated with explosions, just as great rapidity of the propagation of explosions favors this effect. As already stated, these factors are very favorable with carburized acetylene.

Its temperature of ignition is about 150 deg. C., higher than that of acetylene; the heat of combustion is 30 per cent higher than that of acetylene, and the rapidity of explosions is but slightly less. The temperature of combustion, or rather the temperature of the flame, is less elevated, therefore requiring less water for refrigeration.

It must be remarked that in the course of experiments on compression with carburized acetylene no deposit of benzine was discovered, for after compression this gas shows the same composition as before, which is not the case with carburized air.

The figures obtained with carburized acetylene gas exhibit well its economic value. Taking the cost of a cubic meter of acetylene as one franc, and the cost of a kilogramme of benzine as thirty-seven and a half centimes, a cubic meter of carburized acetylene No. 1 costs about 1.10 franc and a cubic meter of gas No. 2, 0.95 franc.

As is shown in Table II., the cost of an incandescent burner of 30 candle power is per hour about 0.09 franc, and 1,000 calories (Table V.) cost 0.052 to 0.059 franc. Comparisons of the expense of heating by means of

other illuminating gases are likewise seen in Table VI. For motive force a consumption of gas costs about 0.15 franc with carburized acetylene, about 0.23 franc with acetylene, and 0.11 franc with lighting gas, counting the cubic meter of acetylene at 1.05 franc and the cubic meter of lighting gas at 0.20 franc.

But the force of the motor with carburized acetylene is much higher than that of a motor with ordinary gas or that of a motor with pure acetylene, as the pressure can be much greater. A well-constructed motor with carburized acetylene is more economical than any other motor from the great simplicity of its organs.

In regard to economy, carburized acetylene offers for lighting the same advantages as pure acetylene; for heating and motive force it is greatly superior.

TABLE VI.
Cost of 1,000 Calories.

	Franc (about).
Coal-gas	0.04
Carburized acetylene	0.05
Carburized air	0.06
Acetylene	0.08
Acetylene (central works)	0.15

In all its applications carburized acetylene may enter into competition with ordinary lighting gas.

Compared with pure acetylene, carburized acetylene presents the advantage of being less explosive, especially when it is only slightly carburized, without considering that this gas does not yield liquid as strongly carburized gas does, when the temperature is lowered.

The arrangement of a simple carbureter fixed to any furnace whatever or to a motor makes it possible to convert this slightly carburized gas, when desired, into strongly carburized gas.

It is to be hoped that the difficulties which still prevent the adoption of incandescent lighting with acetylene and the employment of carburized acetylene may be soon overcome, for there is a vast field for the development of this industry.

[Continued from SUPPLEMENT No. 1515, page 24274.]

EXPERIMENTAL ELECTROCHEMISTRY.*

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Assistant Professor of Chemistry in the George Washington University, Washington, D. C.

FIFTH PAPER.

THE VELOCITY OF ELECTROLYTIC CONDUCTION.

Experiments with a High-Speed Special Chronograph Capable of Dividing a Second Into a Million Parts.

Absolute Velocity of Ions.

IT will be recalled that in the preceding chapter ions were made to travel by induction. In the experiment with the electrical machine, the two vessels connected by means of the wet string, and the capillary, the electrostatic charging of the electrolyte took place at once. In other words, as soon as the electrical machine was started, bubbles of hydrogen gas made their sudden and immediate appearance within the capillary. Now, as a matter of fact, the bubbles of gas would make their appearance at once, whether this wet string conductor was long or short. The electrical conduction would be instantaneous, and yet we will learn a little later in the present chapter, under the heading "Absolute Velocities of the Ions," that the ions themselves move very slowly, and have different velocities. How can we account, therefore, for the instantaneous conduction of an electrolyte, when the ions which carry the electricity upon them move very slowly, and have their respective velocities? We can only account for the facts in such an experiment by attributing the instantaneous conduction to be due to free ions already present about the electrodes. Fig. 1 represents an experiment of Prof. Ostwald's to show the instantaneous electrical conduction through electrolytes. Here we have a glass tube about 50 centimeters long and 1 centimeter in diameter bent at right angles at the ends and enlarged into cylindrical terminals as shown. At the left we have a stick of chemically-pure zinc supported in position by a cork. At the right we have a bent-tube manometer containing a little colored water, supported by a good tight cork also. At the bend on the right a platinum wire is fused in place to act as the other terminal or electrode. The tube is filled with dilute sulphuric acid. Upon connecting this piece of apparatus with a battery, motor-generator, or lamp bank as described in the first chapter, making the zinc the anode, and the platinum wire the cathode, bubbles of hydrogen appear instantly upon the platinum wire, and a pressure is indicated upon the water gage. The instantaneous appearance of bubbles of hydrogen with the closing of the contact key in series with the source of electricity, goes to prove the presence of free ions already about the electrodes. These free ions merely give up their charges and escape upon completing the circuit. Now, if it was necessary for the electric current to first decompose or break up the molecule of sulphuric acid, then the two atoms of hydrogen replaced by the zinc in the SO_4 radical must have traveled to the platinum-wire cathode through the tube, which is 50 centimeters long. Now there are experiments, as we shall see at the close of this chapter, to determine the absolute velocities of ions, and measurements upon the velocity of the hydrogen ion show that it would require a long time for hydrogen ions to travel through a tube 50 centimeters long. Now, hydrogen appears at once upon closing the circuit, and we must attribute the immediate response or conductivity of the solution to free ions already around the electrodes in readiness to discharge their electricity. Although this experiment of Prof. Ostwald is one of great interest, it struck the present writer as being very crude and rough, and capable of great improvement. It does not answer many vital questions. For example, do all electrolytes conduct with the same velocity? In other words, will an electrolyte consisting of heavy ions respond, or conduct, as quickly as an electrolyte consisting of light ions? Will all electrolytes conduct as quickly as a metallic conductor? This appeared to be neglected as a piece of research work; and with a view of comparing different electrolytes with each other both in solution and in igneous fusion, and in comparing electrolytes with metallic conductors, the special high-speed chronograph was designed and built as illustrated in the following drawings. Through the agency of this chronograph a dynamo current was compared with the current from a set of accumulators, and light thrown upon such questions as mechanical movement of ions of different weights, involving the question of inertia. Let us first compare electrolytic conduction in an electrolyte with metallic conduction, for if the two act in the same time, the evidence in favor of free ions is conclusive. Fig. 2 outlines in diagram the chronograph cylinder and the electrolyte and wire respectively. Here *A* represents the electrolyte in the glass tube, and *B* the parallel metallic conductor. *C* is a rheostat in series with the metallic conductor to bring the same to an equal ohmic resistance with the electrolyte. *D* represents a delicate ammeter in series with the electrolyte and the electro-magnet *E* of the chronograph.

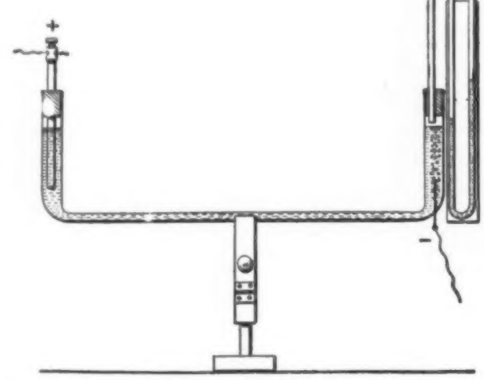

Fig. 1.—Prof. Ostwald's Experiment to Show Instantaneous Electrical Conduction Through an Electrolyte.

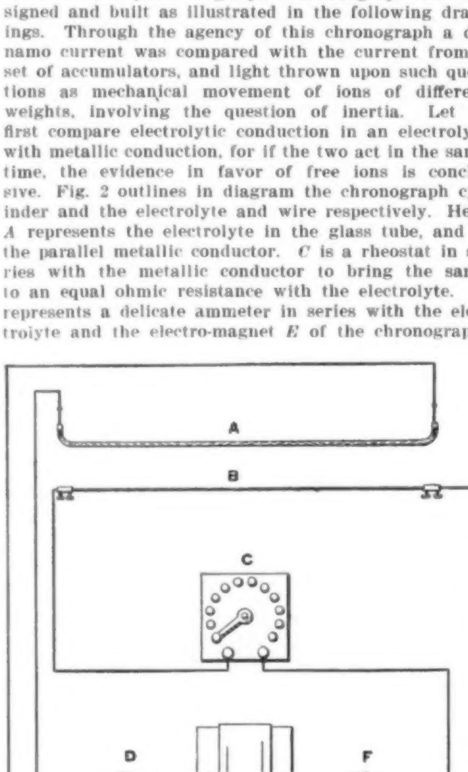

Fig. 2.—Diagram of Author's Method of Studying Time Required for Electric Currents to Traverse Electrolytes, and to Compare the Time with that Required by Metallic Conductors. A. Electrolyte. B. Parallel Wire. C. Rheostat for Balancing Resistance of Wire to that of Electrolyte. D. Mill-Ammeter in Series with Electrolyte and Magnet E. At F the Mill-Ammeter is Shown Shifted in Series with Wire and Magnet G. H. Double Switch for Closing Both Circuits Simultaneously.

F represents in dotted lines the same ammeter shifted in series with the metallic conductor and the electro-magnet *G* of the same chronograph. *H* illustrates a double switch for simultaneously closing both circuits after the resistances of the two have been balanced, or made carefully equal to each other. By revolving the chronograph cylinder and closing the switch, the two electro-magnets will strike the paper band upon the chronograph cylinder, and draw records by means of soft lead-pencil points. The chronograph and magnets must first be most carefully calibrated by connecting the magnets in series with each other, on one and the same circuit, thereby supplying a common current of electricity, and adjusting their springs and striking distances until a current of common value will cause both magnets to strike upon the rapidly-revolving cylinder at the same instant. This can most easily be seen by the pencil records. When by careful experiment and adjustment the two electro-magnets strike "abreast" upon the flying cylinder, which is driven by a high-speed electric motor, the series connection is changed, and each electro-magnet is placed separately in circuit with electrolyte and wire respectively, previously made of equal ohmic resistance. The lines upon the cylinder in this drawing illustrate the appearance of the pencil record when the cylinder is driven at moderately high speeds. A photograph of such a chronograph is given in Fig. 3, where an electric motor is directly connected by means of a flexible coupling to reduce vibration. It

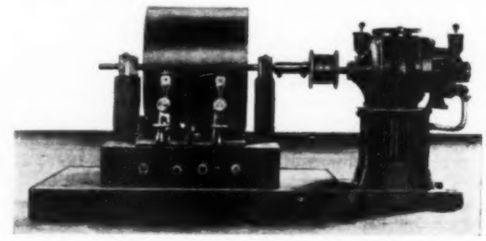

Fig. 3.—Photograph of Simple Drum High-Speed Chronograph Direct Connected to Electric Motor.

was soon found, however, with such a simple chronograph cylinder, when driven at very high speeds, that the pencil records were drawn all the way around, and it was impossible to see where the contacts were first made. It became necessary to expand the chronograph by driving a long band of paper. Fig. 4 and 5 will make the plan clear. In Fig. 4 the end of the chronograph cylinder is again shown, with its electric driving motor at the right, and with a heavy balance wheel to steady its rapid motion at the left. A revolution counter is also depicted at the extreme left, pressed against the shaft of the chronograph cylinder. This revolution counter was afterward moved to the shaft of the pulley at the far end of the band, as being a fairer place, for in case there was a slight creeping of the band upon the chronograph cylinder, there would be no error introduced from this cause. Fig. 5 illustrates a side view of this special form of band chronograph, showing its band and supporting drum-wheel at the far end of the work table over which it runs. The arrangement of the marking pencils and electro-magnets is made clear in this illustration. Upon the work bench or table are the electrolyte and wire respectively, together with the picture of a cell or storage battery and a special form of U-tube used for various conduction experiments with electrolytes. This particular chronograph revolves at the rate of two thousand revolutions per minute, and it will be seen that the slightest "lag" in conductivity in either circuit, when the two are closed simultaneously by a proper key, will be shown accurately and quantitatively upon the moving band. With this arrangement, as will be seen from the following mathematical exposition, a second may be divided into one hundred thousand parts; and by higher speeds the second may be laid off and divided into a million parts, dependent upon the behaviors of the various conductors experimented with. The diameter of the chronograph cylinder being 15 centimeters, we can take this as a basis upon which to start the calculation.

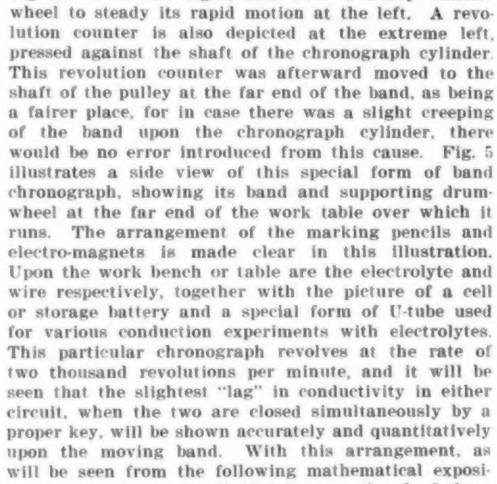

Fig. 4.—Rear View of Electro-Chronograph Provided with Electric Motor, Balance Wheel and Revolution Counter. This Instrument is a Modification of that shown in Fig. 3, as it Drives a Long Band of Paper for Receiving Record.

3.14159
15 cm. diameter

1570795
314159

47.12385 cm. circumference

With 2,000 revolutions per minute, we have 47.12385 × 2,000 = 94247.70 centimeters per minute. The space traveled during one second is therefore

60) 94247.70 (1504.1283 cm.

In 1/10 second we have 150.41283 cm.
In 1/100 second we have 15.041283 cm.
In 1/1,000 second we have 1.5041283 cm.
In 1/10,000 second we have .15041283 cm.

Working with a chronograph of still higher speed,

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT

the cylinder being driven by a two-horse-power motor belted up for speed, the scale upon the flying band was of course still more open, and allows of determinations to be made to 1/100,000 and even 1/1,000,000 of a second. A tabulated length of spaces upon this high-speed band is as follows up to hundred-thousandths of a second. The figures are as follows:

Cm. circumference. Rev. per min. Cm. traveled.
47.12385 × 10,000 = 471238.5 cm. per min.
60)471238.5(7853.97500 cm. per second.
In 1/10 second we have 785.397500 cm.
In 1/100 second we have 78.5397500 cm.
In 1/1,000 second we have 7.85397500
In 1/10,000 second we have .785397500
In 1/100,000 second we have .0785397500

For higher speeds still and correspondingly more minute subdivisions of the second, a chronograph

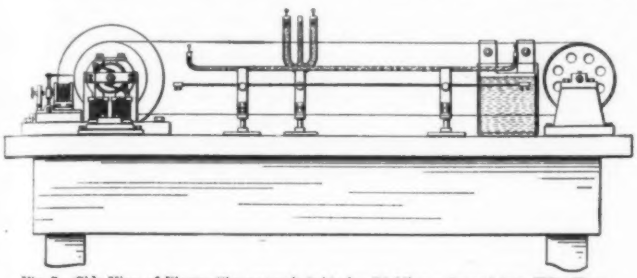

Fig. 5.—Side View of Electro-Chronograph Table for Dividing a Second into Fifty Thousand Parts in Connection with an Electrolyte for Studying the Velocity of Electrolytic Conduction. The Paper Record Band is Shown Passing Over the Loose Drum-Wheel at the Extreme Right.

rigged like that shown in Fig. 6 was experimented with. Here we have an electrolyte 50 feet long in the glass tube arranged like a steam radiator, and the chronograph cylinder driven at enormous speed by the multiplying system of belting to the countershaft, etc. The telephone receiver, cell of battery, induction coil, and resistance set depicted here were employed to balance the resistances with, instead of the ammeter employed in the slower-speed design of instrument. The method of measuring resistances by means of the telephone and induction coil is known as Kohlrausch's method, and consists of the simple Wheatstone bridge arrangement with a telephone receiver in the place of a galvanometer, and the alternating current from the secondary of a small induction coil, instead of a simple battery of cells. With this arrangement the alternating current produces a humming sound in the telephone when the bridge is out of balance. The alternating current in addition does not decompose the electrolyte, and allows of conductivity determinations being made with great accuracy. Having described the apparatus, some of the results will now be given. The first experiments were made with an electrolyte consisting of dilute sulphuric acid, in the proportion of 10 cubic centimeters of H_2SO_4 specific gravity 1.84664 in 40 cubic centimeters of distilled water, and a wire of German silver made equal in resistance by means of a rheostat of the *non-inductive type.* This is an important point to observe in determining all resistances where only a momentary current is to be dealt with. For a dissertation upon the subject of non-inductive resistances, the student must be referred to any standard work on physics dealing with electrical measurements. The present writer may say, however, that with common coil resistances, or rheostats, there is a choking or damping effect upon electrical impulses of short duration, due to the phenomenon of self-induction. Having balanced the respective resistances of the electrolyte and wire with its *non-inductive resistance* rheostat in series, the chronograph was speeded up, and when a rate of 2,000 revolutions per minute was reached, as counted by the revolution counter upon the *drum-wheel shaft,* the key was closed three times in rapid succession, and the chronograph stopped. Three records had been made. At first it was found that the electro-magnet in series with the electrolyte struck a trifle in advance of the electro-magnet in series with the wire, the marking on the band leading by 0.75 centimeter indicating that the conductivity through the electrolyte was ahead by 1/10,000 of a second. What was this due to? Although the two resistances were balanced as carefully as possible, the leading of the electrolyte was undoubtedly due to the fact that its resistance was slightly lower than that of the wire. The resistances were carefully rebalanced, using the most refined means, when the two conductors finally "struck abreast," so to speak, upon the flying band. Electrolytes of various composition were substituted for the sulphuric acid, and carefully compared with the wire, and in every case where the resistances had been perfectly balanced, the two electro-magnets struck abreast. The highest speeds of bands were of course obtained with the large instrument as shown in Fig. 6, and with this equipment, electrolytes of various lengths were experimented with. An electrolyte 50 feet in length conducted as

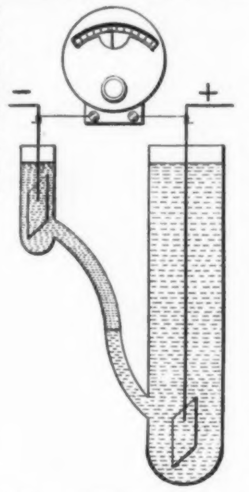

Fig. 8.—Whetham's Apparatus for Experimentally Determining the Absolute Velocities of Ions.

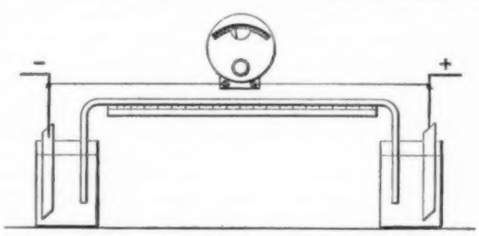

Fig. 7.—Lodge's Apparatus for Experimentally Determining the Absolute Velocity of the Hydrogen Ion.

quickly as an electrolyte only a few centimeters long. It mattered not whether we used an electrolyte with light or heavy ions, the rate of conductivity, or response to the electric current, was the same. Experiments were also conducted with storage batteries as a source of electricity, and it was recorded here again that the electricity left the free ions in the storage cells, as readily as it did a wire charged by a dynamo current. Experiments of this character were repeated many times, and the writer believes one is justified in stating the law that *electrolytes of equal resistance conduct the electric current with a definite velocity, regardless of the composition of the electrolytes or the length of the containing vessel.* It may also be stated that *an electrolyte conducts the electric current as quickly as a conductor of the first class, regardless of its composition, provided we have an equal ohmic resistance of a non-inductive type.* In working with fused electrolytes the same quantitative behavior was observed, the electric current flowing as quickly after contact as with all metallic conductors. Free ions must therefore be around the electrodes, and in contact with them. If molecules had to be first broken down into ions, and these ions had to travel, there would undoubtedly be a lag in experimenting with electrolytes consisting of heavy ions, for the question of inertia would be involved. The same impulse which would start up light ions in a given time, would fail to produce the same response where heavier ions were concerned. Having shown the instantaneous behavior of electrolytes toward the electric current, we are now in a position to study the experimental methods for measuring the absolute velocity of ions.

Absolute Velocity of Ions. Experimental Methods for Showing Lodge's Apparatus.

It has been stated that all ions had their respective velocities, and that these velocities were exceedingly small. It has been demonstrated by Bredig, and also by Ostwald, that the velocity of mechanical motion of the ions is a function of their atomic weights. This relationship was brought out by series of long and patient research, but the reason for such behavior is not understood. We have in chemistry several striking cases of periodic behavior, although we have so far been unable to account for them. If we arranged the ions in a table according to their migration rates, we would find that hydrogen is the swiftest of them all, although its movement through an electrolyte requires considerable time. Let us look into the method of Lodge, and learn just what the speed of the hydrogen ion is. Fig. 7 illustrates the apparatus of this physicist for determining the speed of the hydrogen ion under a given potential gradient. Here we have two beakers or glass jars joined by a siphon tube bent at right angles at each end. A centimeter scale is attached to the under side of this tube as indicated. This glass siphon tube contains an aqueous solution of gelatine put in hot, which solidifies when cold, forming a jelly. Now this solution of gelatine also contains some sodium chloride, NaCl, to serve as the electrolyte, and the entire solution is colored red by the addition of a little phenolphthalein made alkaline with a few drops of sodium hydroxide solution. The gelatine is dissolved in hot water in a beaker and some common salt (sodium chloride) is added and stirred until a perfectly homogeneous solution is obtained. A little phenolphthalein is then stirred in and made red by adding a few drops of the sodium hydroxide solution. This mixture is kept near the boiling point of water for a few minutes, and is then poured into a number of tubes bent at right angles to form siphons like that illustrated. Care must be taken to avoid the inclosing of air bubbles, and the tubes are put away to cool and solidify with the bent ends turned up. To measure the velocity of the hydrogen ion, one of the tubes after cooling is placed dipping into the two beakers as shown, and the beakers filled with a dilute solution of sulphuric acid. Two platinum electrodes are put in place and connected to our motor-generator or lamp bank, with a voltmeter joined across the electrodes to show the potential gradient under which we are working. All ions have a fixed velocity under a set potential gradient. Now, what takes place when a current of electricity is made to pass through this system? The hydrogen ion from the electrolyte of sulphuric acid starts from the anode in the right-hand beaker, and makes its way to the cathode in the left-hand beaker through the composition in the siphon tube. What happens there? The hydrogen simply displaces the sodium from the sodium chloride present, and forms hydrochloric acid, $H + NaCl = HCl$, which decolorizes the gelatinous solution of phenolphthalein. This indicator is red in the presence of a base, and colorless in the presence of an acid. As the hydrogen ion proceeds through the siphon tube, it replaces the sodium in the sodium chloride, and bleaches out the phenolphthalein marking its way through the composition. The experiment is an interesting one to watch, as the decoloration proceeds at a slow rate. Lodge worked with a potential gradient equivalent to a drop of one volt a centimeter. If we have a tube 50 centimeters long, therefore we must use a difference in potential of 50 volts, and must employ our lamp bank for this unless we have at hand a dynamo wound for a current output at 50 volts. For a short tube we can use our motor-generator. Working with such a piece of apparatus with a drop of one volt per centimeter, Lodge found the absolute velocity of the hydrogen ion to be about one and two-fifths centimeter per minute. In three determinations Lodge found the hydrogen ion to travel—

1.1560 centimeters per minute.
1.1740 centimeters per minute.
1.1440 centimeters per minute.

The average of these three determinations with the above apparatus being

1.1580 centimeters per minute,

or considerably over an hour for this, the swiftest of all ions to travel a meter; and yet as shown by the electro-chronograph work, an electric current leaps through an electrolyte, so to speak, in exactly the same time as it does through a wire.

Whetham's Method.

Another experimental method for determining the

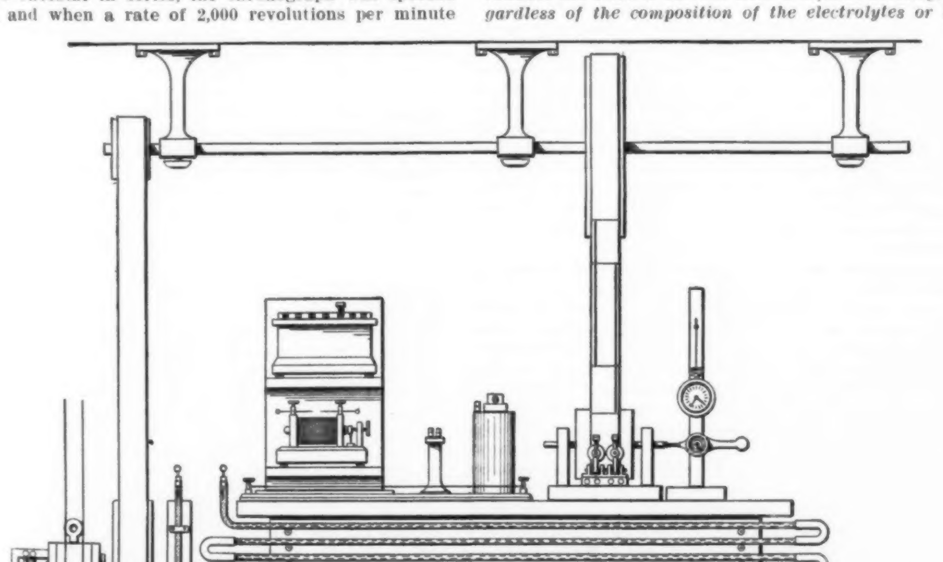

Fig. 6.—Special High-Speed Electro-Chronograph Capable of Dividing a Second into a Million Parts in Connection with Fifty Feet of Electrolyte for Studying Velocity of Electrolytic Conduction. This Chronograph is Driven by a Two-Horse-Power Motor as Shown at the Left Belted Up for Multiplication of Speed.

absolute velocities of ions was devised and used by Whetham, the apparatus being illustrated in Fig. 8. He describes his method as follows: "Suppose we have two solutions like copper chloride and ammonium chloride, containing one ion in common, and having nearly equal conductivities. Let one solution be colored, and have a density different from that of the other. The denser solution is first poured into the longer arm of a kind of U-tube, and then the other is allowed to flow gently on to its surface from the shorter arm. If a current is passed across the junction between the two solutions, it carries the copper and ammonium ions with it, and drives the chlorine ions in the opposite direction. Since the color depends on the presence of the copper ions, the boundary will travel with the current, and, by measuring its velocity, the speed of the ions under unit potential gradient can be calculated." There are several other methods for determining absolute velocities of ions, and in the hands of careful investigators the results agree very strikingly. As will be seen later, there are methods for determining the relative velocities of the ions, and it will be seen at once if we have the absolute velocity of one ion accurately determined, and we can ascertain in other ways the relative velocities of the remaining ions, we can calculate the absolute velocities of them all. Having learned about electrolytes, dissociation, and ionic velocity, etc., we will be in a good position to take up and appreciate work of a little more practical character in our next chapter, and introduce the student to the beautiful work of Faraday in electrochemical science. Here we will study the quantitative relation of the electric current to electrolytes, and take up the energy relations between chemistry and electricity, and lay the foundation for work of a very practical and useful character.

(To be continued.)

[Concluded from SUPPLEMENT No. 1516, page 24294.]

BREEDING AND HEREDITY.*

WILLIAM BATESON, M.A., F.R.S.

GAMETIC UNIONS AND THEIR CONSEQUENCES.

CHARACTERS being then distributable among gametes according to regular systems, the next question concerns the properties and features presented by the zygotes formed by the union of gametes bearing different characters.

As to this no rule can as yet be formulated. Such a heterozygote may exhibit one of the allelomorphic characters in its full intensity (even exceeding it in special cases, perhaps in connection with increased vigor), or it may be intermediate between the two, or it may present some character not recognizable in either parent. In the latter case it is often, though not always, reversionary. When one character appears in such intensity as to conceal or exclude the other it is called *dominant*, the other being *recessive*. It may be remarked that frequently, but certainly not universally (as has been stated), the phylogenetically older character is dominant. A curious instance to the contrary is that of the peculiar arrangement of colors seen in a breed of game fowls called Brown-breasted, which in combination with the purple face, though certainly a modern variation, dominates (most markedly in females) over the black-breasted type of *Gallus bankiva*.

In a few cases irregularity of dominance has been observed as an exception. The clearest illustration I can offer is that of the extra toe in fowls. Generally this is a dominant character, but sometimes, as an exceptional phenomenon, it may be recessive, making subsequent analysis very difficult. The nature of this irregularity is unknown. A remarkable instance is that of the blue color in maize seeds (Correns; R. H. Lock). Here the dominance of blue is frequently imperfect, or absent, and the figures suggest that some regularity in the phenomenon may be discovered.

Mendel is often represented as having enunciated dominance as a general proposition. That this statement should still be repeated, even by those who realize the importance of his discoveries, is an extraordinary illustration of the oblivion that has overwhelmed the work of the experimental breeders. Mendel makes the specific statement in regard to certain characters in peas which do behave thus, but his proposition is not general. To convict him of such a delusion it would be necessary to prove that he was exceptionally ignorant of breeding, though on the face of the evidence he seems sufficiently expert.

A generalization respecting the consequences of heterozygosis possessing greater value is this: When a pair of gametes unites in fertilization the characters of the zygote depend directly on the constitution of these gametes, and not on that of the parents from which they came. To this generalization we know as yet only two clear exceptions. These very curious cases are exactly alike in that, though segregation obviously occurs in a seed-character, the seeds borne by the hybrid (F_1) all exhibit the hybrid character, and the consequences of segregation in the particular seed-character are not evident until the seeds (F_2) of the second (F_1) generation are determinable. Of these the first is the case of indent peas investigated especially by Tschermak. Crossed with wrinkled peas I have found the phenomena normal, but when the cross is made with a round type the exceptional phenomena occurs. The second case is that discovered by Biffen in the cross between the long-grained wheat called Polish and short-grained Rivett wheat, demonstrations of which will be laid before you. No satisfactory account of these peculiarities has been yet suggested, but it is evident that in some unexplained way the maternal plant characters control the seed characters for each generation. It is, of course, likely that other comparable cases will be found.

Appearances have been seen in at least four cases (rats, mice, stocks, sweet peas) suggesting at first sight that a heterozygosis between two gametes, both extracted, may give, e. g., dominance; while if one, or both, were pure, they would give a reversionary heterozygote. If this occurrence is authenticated on a sufficient scale, we shall of course recognize that the fact proves the presence in these cases of some pervading and non-segregating quality, distributed among the extracted gametes formed by the parent heterozygote. As yet, however, I do not think the evidence enough to warrant the conclusion that such a pervading quality is really present, and I incline to attribute the appearances to redistribution of characters belonging to independent pairs in the manner elucidated by Cuénot. The point will be easily determined, and meanwhile we must note the two possibilities.

Following, therefore, our first proposition, that the gametes belong to definite classes, comes the second proposition, that the unions of members of the various classes have specific consequences. Nor is this proposition simply the truistical statement that different causes have different effects; for by its aid we are led at once to the place where the different cause is to be sought—Gametogenesis. While formerly we hoped to determine the offspring by examining the *ancestry* of the parents, we now proceed by investigating the *gametic composition* of the parents. Individuals may have identical ancestry (and sometimes, to all appearances, identical characters), but yet be quite different in gametic composition; and, conversely, individuals may be identical in gametic composition and have very different ancestry. Nevertheless, those that are identical in gametic composition are the same, whatever their ancestry. Therefore, where such cases are concerned, in any considerations of the physiology of heredity, ancestry is misleading and passes out of account. To take the crudest illustration, if a hybrid is made between two races, A, B, and another hybrid between two other races, C, D, it might be thought that when the two hybrids AB and CD are bred together, four races, A, B, C, and D, will be united in their offspring. This expectation may be entirely falsified, for the cell-divisions of gametogenesis may have split A from B and C from D, so that the final product may contain characters of only two races after all, being either AC, BC, AD, or BD. In practice, however, we are generally dealing with *groups* of characters, and the union of all the A group, for instance, with all the C group will be a rare coincidence.

It is the object of Mendelian analysis to state each case of heredity in terms of gametic composition, and thence to determine the laws governing the distribution of characters in cell-divisions of gametogenesis.

There are, of course, many cases which still baffle our attempts at such analysis, but some of the most paradoxical exceptions have been reduced to order by the accumulation of facts. The consequences of heterozygosis are curiously specific, and each needs separate investigation. A remarkable case occurred in stocks, showing the need for caution in dealing with contradictory results. Hoary leaves and glabrous leaves are a pair of allelomorphic characters. When glabrous races were crossed with crossbreds, sometimes the results agreed with simple expectation, while in other cases the offspring were all hoary when, in accordance with similar expectation, this should be impossible. By further experiment, however, Miss Saunders has found that *certain* glabrous races crossed together give nothing but hoary heterozygotes, which completely elucidates such exceptions. There is every likelihood that wherever segregation occurs similar analysis will be successful.

Speaking generally, in every case the first point to be worked out is the magnitude of the character-units recognized by the critical cell-divisions of gametogenesis, and the second is the specific consequence of all the possible combinations between them. When this has been done for a comprehensive series of types and characters, it will be time to attempt further generalization, and perhaps to look for light on that fundamental physiological property, the power of cell-division.

Segregation and Sex.—Acquaintance with Mendelian phenomena irresistibly suggests the question whether in *all* cases of families composed of distinct types the distinctness may not be primarily due to gametic segregation. Of all such distinctions none is so universal or so widespread as that of sex; may it not be possible that sex is due to a segregation occurring between gametes, either male, female, or both. It will be known to you that several naturalists have been led by various roads to incline to this view. We still await the proof of crucial experiments; but without taking you over more familiar ground, it may be useful to show how the matter looks from our standpoint. As regards actual experiment, all results thus far are complicated by the occurrence of some sterility in the hybrid generation. Correns, fertilizing ♀ *Bryonia dioica* with pollen from ☿ *B. alba*, obtained offspring (F_1) *either* ♂ or ♀ with only one doubtful exception. Gärtner found a similar result in *Lychnis diurna* ♀ × ☿ *L. Flos-cuculi* as ♂, but only raised six plants (4 ♂, 2 ♀). From *L. diurna* ♀ × ☿ *Silene noctiflora* as ♂ he got only two plants, spoken of as females which developed occasional anthers. These results give a distinct suggestion that sex may be determined by differentiation among the male gametes, but satisfactory and direct proofs can only be obtained from some case where sterility does not ensue.

Apart, however, from such decisive evidence—which, indeed, would be more satisfactory if relating to *animals*—several circumstances suggest that sex is a segregation-phenomenon. Prof. Castle in a valuable essay has directed attention to distinct evidence of disturbance in the heredity of certain moths (*Aglia tau* and *lugens*, Standfuss's experiments; *Tephrosia*, experiments of Bacot and others, summarized by Tutt),* where the disturbance is pretty certainly connected with sexual differentiation. Mr. Punnett and I are finding suggestions of the same thing in certain poultry cases. Mr. Doncaster has pointed out that the evidence of Mr. Raynor clearly indicates that a certain variety of *Abraxas grossulariata*, usually peculiar to the female, is a Mendelian recessive. It is scarcely doubtful that this will be shown to hold also for some other female varieties, e. g., *Colias edusa*, var. *helice*, etc. We can therefore feel no doubt that there is some entanglement between sex and gametically segregable characters. A curious instance of a comparable nature is that of the Cinnamon canary (Norduijn, etc.), and similar complications are alleged as regards the descent of color-blindness and hæmophilia.

In one remarkable group of facts we come very near to the phenomenon of sex. Experiments made in conjunction with Mr. R. P. Gregory have shown that the familiar heterostylism of Primula is a phenomenon of Mendelian segregation. Short style, or "thrum," is a dominant—with a complication;† long style, or "pin," is recessive; while equal, or "homostyle," is recessive to both.

Even nearer we come in a certain sweet-pea example, where abortion of anthers behaves as an ordinary Mendelian recessive character.‡ By a slight exaggeration we might even speak of a hermaphrodite with barren anthers as a "female."

Consider also how like the two kinds of differentiation are. The occasional mosaicism in Lepidoptera, called "gynandromorphism," may be exactly paralleled by specimens where the two halves are two color-varieties, instead of the two sexes. Patches of *Silene inflata* in this neighborhood commonly consist of hairy and glabrous individuals,§ a pheonomenon proved in Lychnis to be dependent on Mendelian segregation. The same patch consists also of female plants and hermaphrodite plants. Is it not likely that both phenomena are similar in nature? How otherwise would the differentiation be maintained? The sweet-pea case I have spoken of is scarcely distinguishable from this. I therefore look forward with confidence to the elucidation of the real nature of sex—that redoubtable mystery.

We now move among the facts with an altogether different bearing. "Animals and Plants under Domestication," from being largely a narration of inscrutable prodigies, begins to take shape as a body of coherent evidence. Of the old difficulties many disappear finally. Others are inverted. Darwin says he would have expected "from the law of reversion" that nectarines being the newer form would more often produce peaches than peaches nectarines, which is the commoner occurrence. Now, on the contrary, the unique instance of the Carclew nectarine tree bearing peaches is more astonishing than all the other evidence together!

Though the progress which Mendelian facts make possible is so great, it must never be forgotten that as regards new characters involving the addition of some new factor to the pre-existing stock we are almost where we were. When they have been added by mutation, we can now study their transmission; but we know not whence or why they come. Nor have we any definite light on the problem of adaptation; though here there is at least no increase of difficulties.

Besides these outstanding problems, there remain many special points of difficulty which on this occasion I cannot treat—curiosities of segregation, obscure aberrations of fertilization‖ (occasionally met with), coupling of characters, and the very serious possibility of disturbance through gametic selection. Let us employ the space that remains in returning to the problem of variation, already spoken of above, and considering how it looks in the light of the new facts as to heredity. The problem of heredity is the problem of the manner of distribution of characters among germ-cells. So soon as this problem is truly formulated, the nature of variation at once appears. For the first time in the history of evolutionary thought, Mendel's discovery enables us to form some picture of the process which results in genetic variation. It is simply the segregation of a new kind of gamete, bearing one or more characters distinct from those of the

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* Read before the section of zoology of the British Association for the Advancement of Science.

* Trans. Ent. Soc. Lond. 1898.

† It is doubtful if "thrum" ever breeds true, as both the other types can do. Perhaps "thrum" is a Halbrasse of De Vries.

‡ Neglecting minor complications, the descent is as follows: Lady Penzance ♀ × Emily Henderson (long pollen) ♂ gave purple F_1. In one F_2 family, with rare exceptions, colored plants with dark axils were fertile, those with light axils having ♂ sterile, whites being either fertile or sterile. The ratios indicated are 9 colored, dk. ax., fertile ♂ : 3 colored, l. ax., sterile ♂ : 3 white, fertile ♂ : 1 white, sterile ♂. The fertile whites, therefore, though light-axiled (as whites almost always are), presumably bear the dark-axil character, which generally cannot appear except in association with colored flowers. This can be proved next year. Some at least of the plants with sterile ♂ are fertile on the ♀ side, and when crossed with a colored light-axiled type will presumably give only light-axiled plants.

§ This excellent illustration was shown me by Mr. A. W. Hill and Mr. A. Wallis. A third form, glabrous with hairy edges to the leaves, also occurs.

‖ In view of Ostenfeld's discovery of parthenogenesis in Hieracium, the possibility that this phenomenon plays a part in some non-segregating cases needs careful examination.

type. We can answer one of the oldest questions in philosophy. In terms of the ancient riddle, we may reply that the owl's egg existed before the owl; and if we hesitate about the owl, we may be sure about the bantam. The parent zygote, the offspring of which display variation, is giving off new gametes, and in its gametogenesis a segregation of their new character, more or less pure, is taking place. The significance and origin of the discontinuity of variation is therefore in great measure evident. So far as pre-existing elements are concerned, it is an expression of the power of cell-division to distribute character-units among gametes. The initial purity of so many nascent mutations is thus no longer surprising, and, indeed, that such initial purity has not been more generally observed we may safely ascribe to imperfections of method.

It is evident that the resemblance between the parent originating a variety and a heterozygote is close, and the cases need the utmost care in discrimination. If, for instance, we knew nothing more of the Andalusian fowl than that it throws blacks, blues, and whites, how should we decide whether the case was one of heterozygosis or of nascent mutation? The second (F_2) generation from Brown Leghorn × White Leghorn contains an occasional Silver-Gray or Duckwing female. Is this a *mutation* induced by crossing, or is it simply due to a recombination of pre-existing characters? We cannot yet point to a criterion which will certainly separate the one from the other; but perhaps the statistical irregularity usually accompanying mutation, contrasted with the numerical symmetry of the gametes after normal heterozygosis, may give indications in simple cases—though scarcely trustworthy even there. These difficulties reach their maximum in the case of types which are *continually* giving off a second form with greater or less frequency as a concomitant of their ordinary existence. This extraordinarily interesting phenomenon, pointed out first by De Vries, and described by him under the head of "*Halb-*" and "*Mittel-Rassen*," is too imperfectly understood for me to do more than refer to it, but in the attempt to discover what is actually taking place in variation it must play a considerable part.

Just as that normal truth to type, which we call heredity, is in its simplest elements only an expression of that qualitative symmetry characteristic of all non-differentiating cell-divisions, so is genetic variation the expression of a qualitative asymmetry beginning in gametogenesis. Variation is a novel cell-division.* So soon as this fact is grasped we shall hear no more of heredity and variation as opposing "factors" or "forces"—a metaphor which has too long plagued us.

We cease, then, to wonder at the suddenness with which striking variations arise. Those familiar with the older literature relating to domesticated animals and plants will recall abundant instances of the great varieties appearing early in the history of a race, while the finer shades had long to be waited for. In the sweet pea the old purple, the red bicolor, and the white have existed for generations, appearing soon after the cultivation of the species; but the finer splitting which gave us the blues, pinks, etc., is a much rarer event, and for the most part only came when crossing was systematically undertaken. If any of these had been seen before by horticulturists, we can feel no doubt whatever they would have been saved. An observer contemplating a full collection of modern sweet peas, and ignorant of their history, might suppose that the extreme types had resulted from selective and more or less continuous intensification of these intermediates, exactly inverting the truth.

We shall recognize among the character-groups lines of cleavage, along which they easily divide, and other finer subdivisions harder to effect. Rightly considered, the sudden appearance of a total albino or a bicolor should surprise us less than the fact that the finer shades can appear at all.

At this point comes the inevitable question, what *makes* the character-group split? Crossing, we know, may do this; but if there be no crossing, what is the *cause* of variation? With this question we come sharply on the edge of human knowledge. But certain it is that if causes of variation are to be found by penetration, they must be specific causes. A mad dog is not "caused" by July heat, nor a moss rose by progressive culture. We await our Pasteur; founding our hope of progress on the aphorism of Virchow, that every variation from type is due to a pathological accident, the true corollary of "*Omnis cellula e cellula.*"

In imperfect fashion I have now sketched the lines by which the investigation of heredity is proceeding, and some of the definite results achieved. We are asked sometimes, Is this new knowledge of any use? That is a question with which we, here, have fortunately no direct concern. Our business in life is to find things out, and we do not look beyond. But as regards heredity, the answer to this question of use is so plain that we may give it without turning from the way.

We may truly say, for example, that even our present knowledge of heredity, limited as it is, will be found of extraordinary use. Though only a beginning has been made, the powers of the breeder of plants and animals are vastly increased. Breeding is the greatest industry to which science has never yet been applied. This strange anomaly is over; and, so far at least as fixation or purification of types is concerned, the breeder of plants and animals may henceforth guide his operations with a great measure of certainty.

There are others who look to the science of heredity with a loftier aspiration; who ask, Can any of this be used to help those who come after to be better than we are—healthier, wiser, or more worthy? The answer depends on the meaning of the question. On the one hand it is certain that a competent breeder, endowed with full powers, by the aid even of our present knowledge, could in a few generations breed out several of the morbid diatheses. As we have got rid of rabies and pleuro-pneumonia so we could exterminate the simpler vices. Voltaire's cry, "*Ecraser l'infâme!*" might well replace Archbishop Parker's Table of Forbidden Degrees, which is all the instruction Parliament has so far provided. Similarly, a race may conceivably be bred true to some physical and intellectual characters considered good. The positive side of the problem is less hopeful, but the various species of mankind offer ample material. In this sense science already suggests the way. No one, however, proposes to take it; and so long as, in our actual laws of breeding, superstition remains the guide of nations, rising ever fresh and unhurt from the assaults of knowledge, there is nothing to hope or to fear from these sciences.

But if, as is usual, the philanthropist is seeking for some external application by which to ameliorate the course of descent, knowledge of heredity cannot help him. The answer to his question is *No*, almost without qualification. We have no experience of any means by which transmission may be made to deviate from its course; nor from the moment of fertilization can teaching, or hygiene, or exhortation pick out the particles of evil in that zygote, or put in one particle of good. From seeds in the same pod may come sweet peas climbing five feet high, while their own brothers lie prone upon the ground. The stick will not make the dwarf peas climb, though without it the tall can never rise. Education, sanitation, and the rest, are but the giving or withholding of opportunity. Though in the matter of heredity every other conclusion has been questioned, I rejoice that in this we are all agreed.

* The parallel between the differentiating divisions by which the parts of the normal body are segregated from each other, and the segregating processes of gametogenesis, must be very close. Occasionally we even see the segregation of Mendelian characters among zygotic cells.

ON THE GENESIS OF TEMPORARY RADIOACTIVITY.

ELSTER and Geitel, two years ago, discovered the radioactivity induced by atmospheric air in negatively-electrified conductors, when the active layer of the latter, after being removed by friction and transferred elsewhere, was found for some hours to produce an action on photographic plates through black paper and a thin aluminium plate, as well as on a dispersion apparatus.

In a memoir presented before a recent meeting of the French Academy of Sciences, Messrs. Ed. Sarasin, Th. Tommasina, and F. J. Micheli, of Geneva, describe their experiments made by the aid of the Elster-Geitel electroscope on the decay of temporary radioactivity. After each set of five readings, lasting for five minutes, the charge of the electroscope was renewed, and driven always to the same potential, the sign being either always the same or alternately positive and negative. Plotting as ordinates the mean of the readings of each series and as abscissæ the minute of taking the fifth reading, the authors obtained a series of curves embodying the laws of decay of temporary radioactivity, the following facts being brought out: The curves are exponential curves, like those representing the decay of the activity induced by the emanation from radioactive bodies, taking likewise an asymptotical form after two to three hours, according to the energy of activity assumed. In the first hour the radioactivity taken by a wire of any metal (silver, copper, aluminium, iron, nickel) diminishes by half; at the end of the second and third hours, the decay is by half, whereas the activity once more falls to a half value only after five to six hours, and afterward in twenty hours, any further action stated after, say, three days being only a slight one.

This law is practically identical for any metals having been radioactively influenced either in ordinary air or in air ionized by X-rays. The effect produced in air assumes the same intensity both with the window open or closed, whereas the action of X-rays disappears if the window remain open during the activation of the wire. The highly activating action of these rays is, however, not found to diminish on being directed away from the wire to be activated. This strong radioactivity induced by X-rays, so far from being due to the direct radiation, is thus produced by the ionization in the surrounding medium, thus showing that in this case the presence of traces of radioactive bodies should not be claimed for explaining the Elster-Geitel effect. When changing alternately the sign of the electroscopic charge, two curves are obtained which cannot be superposed on one another, the positive curve being always higher. The existence of two independent actions is thence inferred, one being more energetic than the other, and the authors are of opinion that this affords experimental evidence that the temporary radioactivity in question contains, like that of radioactive bodies, the two typical kinds of radiation of opposite sign, alpha and beta. As to the different amounts of the two dispersive actions according to the sign of the electroscopic charge, the following explanation is offered: As the dispersive cylinder is charged negatively, it attracts the positive alpha ions given off by the activated wire, while receiving at the same time a certain amount of negative beta ions, which the negative charge of the cylinder has not been able to repel, owing to their high velocity. Their path is directed at right angles to the cylinder surface. These negative ions, instead of diminishing, will augment the charge of the same sign, borne by the electroscope, the effect thus being the same as if they neutralized immediately part of the charge carried along by the positive alpha ions. On the other hand, as the electroscope carries a positive charge, the negative ions will alone be able to supply their charge to the cylinder, the positive ions being all repelled, owing to their very low velocity. The positive discharge should according to the above be considered as normal.

The result of the authors' observations on the dispersion due to wires that are activated by a positive charge, fully bear out the explanation suggested. In fact, part of the effect produced on the cylinder by positive ions being neutralized through the negative ions that travel at right angles to the surface of the negative dispersing cylinder, the fact that wires activated with a positive charge will produce rather a stronger action on the negative charge of the electroscope, should be attributable to the higher speed possessed in this case by the negative ions permitting the negative disperser to repel them. If this repulsion were complete, the two total charges counterbalancing each other, there should be only one curve, and this will be the case if the residual radioactivity be sufficiently weakened, when the two curves become asymptotic, and are found more and more to approach one another until they become identical. From the results above recorded, the existence of a rather intimate connection is inferred between ionization and the genesis of temporary radioactivity. The authors even think these two phenomena to be reciprocal, that is to say, the radioactivation of bodies would be due to the absorption or unstable adhesion of emanation formed during the ionization of the gases, and possibly constituting it, while radioactivity would consist in this adhering emanation being lost by radiation, this emanation being given off continually from radioactive bodies, and giving in turn rise to the ionization of gases.

Correspondence.

THE WORLD'S SUPPLY OF NITRATES.

To the Editor of the SCIENTIFIC AMERICAN:

Prof. William Crookes, of England, has said recently, "The loss of niter mines would be a calamity to humanity second only to the closing of all coal mines." Chile, South America, has supplied the markets of the world for many years from the beds of *caliche*, a soda earth found there, bearing from 6 to 65 per cent of nitrate of soda. The layers of this deposit, which are from 1½ to 12 feet thick, are being rapidly worked out. The highest estimate as to the duration of these beds of caliche is thirty years. Prof. J. Sigfrid Edstrom, an electrician from Norway, excited great interest at the congress at St. Louis by an account of his experiments with an electric oven for converting air into nitric acid for the manufacture of fertilizers. Many years ago it was found that if a very high-potential electric discharge was fired through the air, the mechanical mixture of oxygen and nitrogen would be forced to unite into a stable compound—nitric acid. But electricity has been far too expensive to consider the process of extracting nitrogen from the air as practical. It will not be feasible certainly until the earth has been fully exploited for niter, and the supply proven to be absolutely exhausted. The question of exhaustion of the world's supply of nitrogen became a vital one to the men of science who listened to Prof. Edstrom. The fact was brought out that in Norway, and many other sections of the globe, agricultural interests will suffer, and finally come to an end, if nitrate of soda beds are not discovered, exploited, and the product put upon the market. As saltpeter—niter—is an essential in the making of powder it is contraband of war, hence the countries without niter will suffer a severe handicap if not actual defeat, in time of war. Members of the Science Congress from California excited interest by telling of the discovery of nitrates in Death Valley, California.

Prof. Edstrom and others were eager for further information, which Prof. Larkin requests be sent to the SCIENTIFIC AMERICAN by any one having correct data, so that the knowledge be widely disseminated, and the anxiety as to the world's supply of nitrogen being exhausted will be dispelled. The writer has been closely associated with expeditions of chemists and miners, who have been sent into Death Valley for the purpose of investigating its thirty-six thousand acres. This tract includes vast deposits of nitrate of soda, of potash, and other valuable products, including borax. It is evident, from the facts known, that niter can only exist in nature in the arid regions; and in order to form it the following conditions are necessary: The presence of alkalies or bases, such as magnesia, soda, lime, etc., in a loose and porous state and easily permeable; moisture, but not surcharged; unimpeded access of air; and the presence of animal and vegetable matter, and the nitrifying germs, the latter being microscopic organisms, which produce niter by the oxidation of organic materials and ammonia. This germ fermentation was thought necessary in the old saltpeter yards in the East, now worked out. For there it was the custom to bring earth from the old yard and mix in the earth at the new workings. This was called bringing the "mother-peter" or "seed-peter" to liven the new yard. The conditions of the evaporated lake region known as Death Valley are almost identical with those in Chile. The plain of Tamarugal in Chile resembles in general appearance the desert country of

Southern California. In this plain of Chile, called by Darwin "an ancient seabed," there is much organic matter, as well as salines. In the Death Valley niter beds there is a large amount of organic matter, and even ammonia minerals. Some of the springs show the presence of ammonia. The evaporated lake or great basin known as Death Valley shows to the geologist that the conditions are almost identical with those under which the sea that once covered the pampas of Chile was evaporated.

Some of the points of similarity between the beds of niter in California and those in Chile may be summarized as follows;

1. Both occur only in typical hot, rainless, desert portions of their countries.

2. Both occur in beds where the niter is associated with gypsum, common salt, glauber salt, sulphate of magnesia, etc.

3. Both are found on dried-up sea bottoms, or the residuum of evaporated oceans.

4. The deposits of niter are interrupted in both countries by deposits of salt, borax, borate of lime, soda, etc.

5. The niter beds of Chile are described as varying in breadth, the average being 1,500 feet, and also varying in thickness. In California the beds run from 1,500 feet to over two miles in width, and from three to over six miles in length.

6. In both Chile and California the caliche varies widely in depth, even in spots close to each other, running from a foot to several feet. In both countries "spots" are found that are very pure.

7. In Chile the beds are covered with a crust, called *costra*, that is very hard. This costra is composed of the *debris* of earthy matters cemented together into a conglomerate that contains sand, salt, gypsum, and other salines. In California the beds have a costra of sand, salt, gypsum, etc.; it is not hard, but soft. In Chile the costra has to be blasted, while in California it could be removed with a scraper.

8. In both countries there are layers of boric acid.

9. The colors of the caliche in Chile are yellow, pink, and green. The creamy yellow is the main characteristic of the California beds, but the pink and green are also present.

10. No niter strata are found below the caliche in Chile, while in California nitrates have been found in some of the alternating strata of the terraces of the hills which form the margin of this evaporated sea.

11. In Chile the only nitrate found in commercial quantities is the nitrate of sodium. In the California beds, other nitrates have been found, as well as the nitrate of sodium that promises to be of commercial importance.

12. In brief, the niter of both countries was formed under the same geological conditions, and on the same huge scale.

The facts so far obtained show the existence of quantities on a scale large enough to be of national importance. The per cent of niter in the Death Valley beds is proven by exhaustive analysis to run from 8 to 65 per cent. Lewis E. Aubury, State Mineralogist of California, in 1902 sent geologists and chemists into the valley, which lies partly in Inyo and partly in San Bernardino County, to examine and form some idea of the value of these deposits.

The Salt Lake, Los Angeles, and Tidewater Railroad, owned by Senator Clark, of Montana, which will be completed and equipped for traffic in 1905, passes through the niter lands. The work of developing the property will be greatly facilitated when this railroad from Salt Lake to tidewater *via* Los Angeles is completed. The world will also come more in touch with this arid region, which has been so little known, and whose climate, and other conditions, have been so adversely exaggerated.

M. C. BELL.

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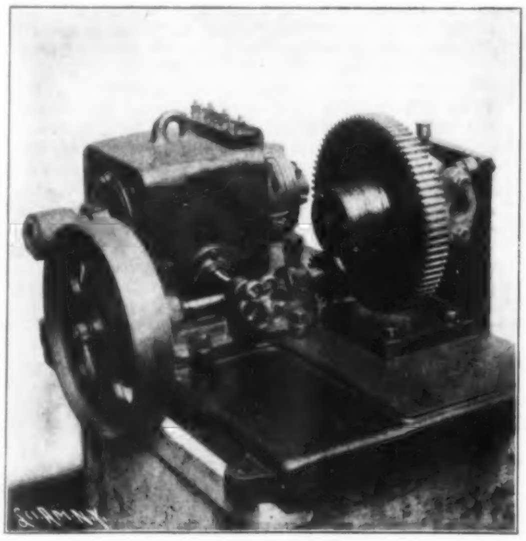
A NEW TYPE OF ROTARY PUMP.*

By EMILE GUARINI.

THE Butin establishment, of Paris, has recently devised a pump based upon a principle which does away with the inconveniences inherent to the old types. This pump is rotary and reversible and gives a true piston stroke like an ordinary pump; but is provided with



THE BUTIN DYNAMO PUMP.

MECHANICALLY-DRIVEN PUMP.

neither valves nor chucks; and, moreover, all the parts revolve in the same direction and at the same angular velocity. These characteristics, in connection with the lightness, simplicity, and strength of the whole arrangement, permit of the application of the principle of these apparatus to hand pumps for all uses and to mechanical ones for industrial purposes. Finally, because of their lightness, these pumps necessitate the use of but little material for their construction, and, on account of their simplicity, they can be manufactured cheaply and be sold at a very low price.

The Butin pump is based upon a new cinematic motion that permits of obtaining signal advantages over other pumping apparatus, and the principle of which is as follows:

In a hemisphere having a certain point as a center, and closed by a cover, revolves a disk around an axis at right angles with its plane. This disk of brass is enlarged and rounded and provided with a groove in which fits a spring-pressed, slidable, semicircular plate guided by suitable H-shaped pieces that fit in the groove. After a 180-deg. revolution of the plate, a volume in the form of a slice of orange is produced, so that this pump may be considered as a true piston apparatus the cylinder of which is equal to this same volume.

The disk, or hemispherical hub, operates like a genuine piston, and is constantly applied throughout its entire surface during the revolution, against the internal surface of the hemisphere, by a spring interposed between the brass and the plate, and through the action of centrifugal force. This double action permits of all wear being taken up automatically; and, as the semicircular form of the plate prevents binding, the latter moves with constant smoothness over the inner surface of the hemisphere, and always presses tightly against it. The hand type of this pump is generally entirely of bronze. The axle is of steel, and, in order to prevent the straining of this, the flywheel that it carries rests through its hub upon the cover. One advantage of this arrangement is that there is no wear of the packing of the stuffing-box, which always remains in a good state. The fixing of the apparatus to any kind of support is effected through cramps cast in a piece with the pump chamber.

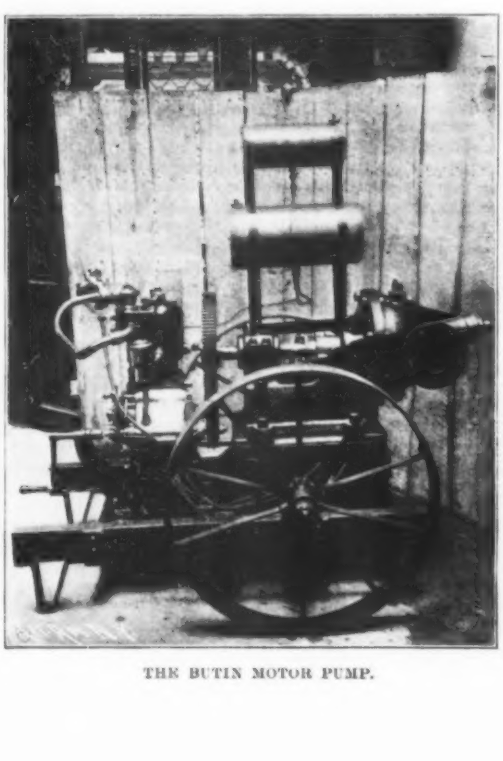
When the depth of the well at which the pump is installed exceeds 26 feet, it becomes necessary to have recourse to special arrangements. If it be desired to obtain a regular or copious discharge, the pump must be placed in the well as near to the surface of the water as possible and be driven by means of a transmission, such as a metallic cable or a pitch-chain. If a source of electric energy is available, a group of electrically-driven pumps may be installed at the bottom of the well.

The Butin apparatus is constructed also in the form of a portable motor pump. This arrangement, which is composed of a pump and a small high-speed gasoline motor, is adapted for industrial applications, as well as private ones. Since it is very light, it is adapted also for temporary installations, and whenever, for want of space, a belt cannot be employed for driving it. If a sufficient space is available, belt driving is to be preferred. In this case, an ordinary industrial mechanical pump is employed. The price is about the same as that of the motor pump, and the arrangement has the advantage that the motor may be more easily set in operation, since it can be done under charge in disconnecting the pump. On the other hand, it is possible to utilize the motor for actuating other apparatus, such as dynamos, agricultural machines, machine tools, etc.

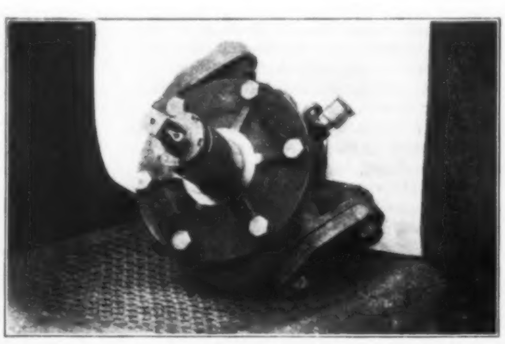
As for the dynamo-pumps mentioned above, they are established either with bipolar dynamos of the armored type, or with bipolar ones of the Manchester type. These groups may be employed for all industrial purposes, public works, agriculture, or irrigation. The types of small discharge but considerable forcing power are particularly well adapted for all domestic applications. They may, for example, be placed in deep wells, and the electric current be furnished by any generator of electricity whatever. Such an arrangement does away with all the transmissions by cable, etc., that are usually employed.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

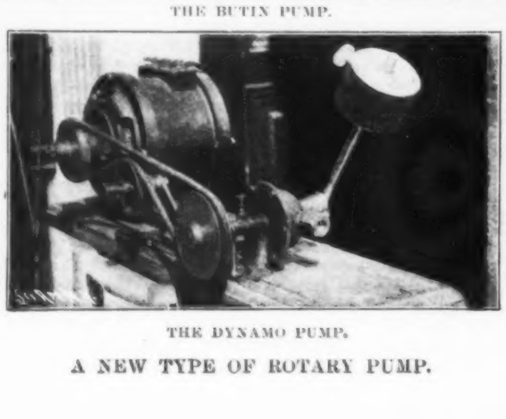
Some interesting tests have recently been carried out by M. Aimé Witz on a 250-horse-power double-acting gas engine working on the Otto cycle, the results of which were recorded in L'Eclairage Electrique. The following are the principal dimensions of the engine, which was built by the Otto Company, of Deutz: Diameter of cylinder, 21.2 inches; stroke, 27.6 inches;



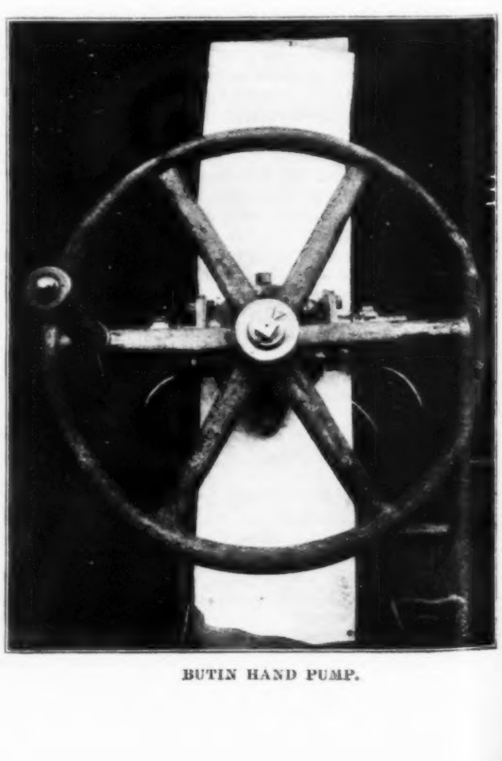
THE BUTIN MOTOR PUMP.



THE BUTIN PUMP.



THE DYNAMO PUMP.



BUTIN HAND PUMP.

A NEW TYPE OF ROTARY PUMP.

speed, 150 revolutions per minute; weight per brake horse-power, 178 pounds. Gas was furnished by a Deutz gas producer, being cleansed solely by two coke scrubbers. The coal used had a calorific value of 14,600 B.T.U. per pound, and contained 3.1 per cent of ashes and 17.1 per cent of volatile substances. With a mean load of 222.5 brake horse-power, the following figures were obtained: Coal consumed by the producer, 161.5 pounds per hour; water consumed in the producer, 140 pounds per hour; ditto in the scrubbers, 3,150 pounds per hour. The temperature of the gas leaving the scrubbers was 170 deg. C., and the calorific value of the gas ranged from 2,280 to 2,444 B.T.U. per pound. As regards the consumption of coal, and of water for cooling the engines, the following figures are quoted: Coal, 0.744 pound per brake horse-power hour; cooling water in the cylinder, 46.7 pounds per brake horse-power hour; cooling water in the piston, 17.6 pounds per brake horse-power hour.

A TWELVE-CYLINDER 150 B.H.P. RACING MARINE GASOLINE MOTOR.

By the English Correspondent of the SCIENTIFIC AMERICAN.

THE development of gasoline-motor-propelled boat racing has resulted in an increasing demand for greater horse-power and accelerated speed, similar to that which attended the development of cars by the organization of automobile races. The outcome is that the gasoline marine motor is being rapidly improved and rendered efficient and reliable for the severe demands which it has to fulfill. One of the latest of these marine engines of this type is the Craig-Dörwald motor, which has recently been completed by the Putney Motor Works, of Putney, London, to the order of a gentleman who intends to participate in such racing contests. This particular engine resembles in general design the standard Craig-Dörwald gasoline motor, which possesses several novel and interesting features, though an important deviation from the standard practice is made by placing the opposite cylinders at an angle.

The engine consists of twelve cylinders cast in pairs. They are ranged in two rows of six each, and are placed diagonally on the crank chamber at an angle of 90 degrees to one another. The advantage of this design is that the opposite cylinders work against one another, resulting in a greater development of power and the utilization of a greater proportion of the developed energy than is possible with vertically-placed cylinders.

Each pair of cylinders is cast in one piece with no joints. This is a conspicuous feature of this type of motor, as the absence of joints to pack prevents any leakage of compression through blowing joints. Extra large water spaces are provided, especially round the valves, so that all possibility of the engine running hot is reduced to a minimum.

The crank chamber is cast out of aluminium, with three large inspection doors placed on the top, and another at the end secured by three nuts. Easy access to the crankshaft is thus assured, while if necessary the bottom of the crank chamber can be quickly withdrawn, being cast in two pieces for this purpose. By the removal of the end plate, the cam shaft actuating the inlet and exhaust valves can be lifted completely out. Both the inlet and exhaust valves are mechanically operated, and, what is another advantage, are interchangeable. The heads of the valves are made of closely-grained cast iron with nickel-steel stems. The latter is forced into the head while it is red hot and riveted over. By the removal of a single nut, any valve can be removed.

The crankshaft is made of nickel steel, and is turned out of a solid single forging. In order to avoid torsion strains, it is of large section. As the special requirements of this engine involve the reduction of weight to the utmost extent, the shaft is hollow, while the webs are also fluted. Furthermore, the shaft is tapered, the greatest diameter of 2¾ inches being at the flywheel end, where the greatest strain is experienced, including the overcoming of the inertia of the flywheel, while at the opposite end the diameter is reduced to 2 inches. The crankshaft, which only weighs 93 pounds, is supported upon four substantial 5-inch phosphor-bronze bearings. Four connecting rods work on each web of the crankshaft. The main feature of the Craig-Dörwald motors is retained in this engine, i. e., the crankshaft is so set that it is in advance of the axis of each cylinder. The advantage derived from this arrangement is that shock and vibration are reduced to almost the minimum. Greater power is furthermore derived from each explosion of the charge within the cylinder, for the piston has a direct, practically vertical thrust downward on the driving stroke; while on the return stroke, when the speed of the piston is at its greatest, it has an appreciably easier passage through the cylinder. A considerable mechanical advantage is thereby gained at the end of the compression stroke of the piston.

The pistons also are of substantial construction, and are 4⅞ inches diameter by 5 inches bore. Heavy connecting rods with equally heavy long bearings are provided. In order to effect an economy in weight, the connecting rods, like the crankshaft, are hollow. This again enables greater efficiency in the lubrication of the piston to be attained. When the connecting rod plunges into the oil in the bottom of the crank chamber, the upward stroke sucks the oil up through the hollow connecting rod, and discharges it at the top over the gudgeon pins. The pistons are machined inside and out, are perfectly balanced, and each is provided with four piston rings. Each of the latter has a novel locking device, which prevents the rings so working round that the four slots may come in line, in which event loss of compression would possibly result.

The arrangement of the gudgeon pins is also ingenious. Instead of projecting through the side and ending flush with the external surface of the piston, lugs for carrying the ends of the gudgeon pins are fitted to each end. These project through the top surface of the piston, and are secured by bolts. The advantage is that by releasing these bolts the piston can be removed entire from the connecting rod for easy examination. Furthermore, it is impossible for any scoring of the cylinder wells to occur from this source. The gudgeon pins are of large diameter, with the center of same near the top of the piston. Side thrust is therefore obviated, and it is also rendered possible to use a short piston and a long connecting rod.

The pistons are placed at an angle of 120 degrees, and no two cylinders are fired simultaneously. The latter are fired in the following sequence: No. 1 is fired first; then its fellow 1A opposite fires, followed by 3 and 3a, and then by 5 and 5a. Firing then recommences from the front, starting with 2 and 2a, then 4 and 4a, followed finally by 6 and 6a. Thus there is a rapid consecutive firing cycle of each of the twelve cylinders, and as each cylinder works against its opposite fellow, the full energy of the developed power is obtained.

The gasoline vapor is supplied from three vaporizers, one of which is placed between each opposite pair of cylinders, thereby supplying four cylinders in all. By this arrangement no cylinder is starved of its requisite quota of explosive mixture. Craig-Dörwald automatic vaporizers are employed, the feature of which is that the necessary quantity of air which the engine desires to render the mixture of the maximum explosive nature, is obtained through an automatic air valve. The harder the engine sucks, the more air is admitted through this valve. Consequently, the mixture of air and gasoline vapor is always automatically adjusted. The extent of the charge admitted into the cylinder is also automatically regulated by means of a long longitudinal piston working on a spring. When the engine is running dead slow and requires only a small charge, this piston, by the action spring, is caused to almost close the inlet passage. Great economy in the consumption of fuel is thereby attained; the possibility of overheating the engine is reduced, and furthermore, the engine is governed by the automatic regulation of the throttle, thereby dispensing with centrifugal governors.

The exhaust gases from the cylinders are conveyed through short, large-diameter gun-metal pipes to a cylindrical exhaust box placed longitudinally between the two rows of cylinders. Sloping backward from the center of this silencer is a short funnel, which carries all the exhaust fumes into the atmosphere without any inconvenience to the passengers within the boat.

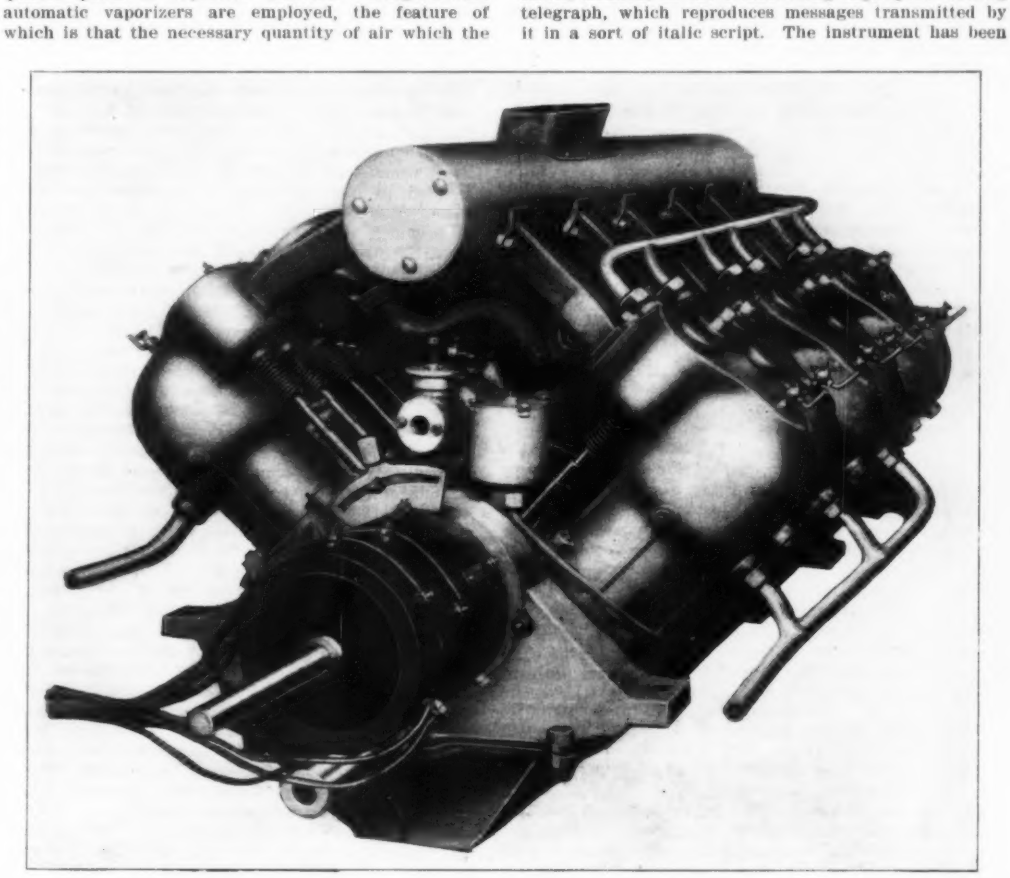
The valve cams are so arranged that by the simple movement of a lever the motor can be stopped quickly and reversed at will. The pinions driving the 2 to 1 gearing are placed within the front of the crank chamber, but are immediately accessible by the removal of the front end plate.

Ignition is by accumulators and coil. A large twelve-wipe contact distributer of the Craig-Dörwald type is fitted on the 2 to 1 shaft at the front of the engine, and two single trembler coils are used.

The engine is self-starting. A device is provided for pumping an explosive charge into each cylinder. To start the engine, it is only necessary to switch on the current. The engine is highly flexible in running, and from 100 revolutions can be accelerated to 900 and even 1,000 revolutions per minute, at which speed it develops 155 B. H. P.

The motor is very compact. It measures 4 feet 3 inches in length, by 2 feet 8 inches wide, and 2 feet in height. The total weight of the motor complete including the flywheel is only 950 pounds. The most prominent feature of the engine is its simplicity and instant accessibility at all parts, two important qualifications for an engine designed for racing purposes, since in the event of a trifling breakdown it is essential that the engine should be so constructed that one can easily and quickly open the crank chamber or pistons in the minimum of time.

The engine is to be installed in a 40-foot boat. The hull is being made of cedar, with a thickness varying from 3-16 inch at the thwarts, gradually increasing to 5-16 and ⅜ inch at the bottom. The engine will be placed somewhat forward of amidships, and the developed power of the engine will be transmitted, through a special reducing gear and a propeller shaft about 20 feet in length, to a single propeller 2 feet 2 inches in diameter.



TWELVE-CYLINDER 150-HORSE-POWER MARINE GASOLINE MOTOR. FRONT VIEW SHOWING ELECTRIC DISTRIBUTER AND VAPORIZER.

POLLAK-VIRAG HIGH-SPEED TELEGRAPH.

A DEMONSTRATION was recently given at the Carlton Hotel, London, of the Pollak-Virag high-speed writing telegraph, which reproduces messages transmitted by it in a sort of italic script. The instrument has been very fully described in the columns of the SCIENTIFIC AMERICAN SUPPLEMENT. It uses two live wires and an earth return, and, unlike writing telegraphs in general, does not involve the maintenance of synchronism between the receiver and transmitter. At the transmitting end the message is sent by means of a perforated paper strip, which is punched with two sets of perforations by means of a machine with a keyboard like that of a typewriter. This strip, the material of which is a non-conductor of electricity, is passed over a roller made up of six electrically insulated sections, and metal brushes pressing on the roller form electrical connection with one or other of these sections whenever a perforation comes opposite them. The currents thus allowed to pass vary in intensity, and those from one group of three sections go to one telephone at the receiving end while those from the other group of three go to a second telephone. To the diaphragms of these two telephones, which are placed close together, a mirror is connected, and is so suspended that it is free to move both horizontally and vertically, in unison with the movements of the diaphragms. Now the perforations which energize one telephone are arranged to represent the vertical motion necessary in writing a character or figure, while the other set of perforations similarly represents the horizontal component. Hence the two telephones together reproduce these components and the result is that under their combined influence the mirror moves in such a way that its motions mark out the complete characters. These motions are imperceptible directly, but if a pencil of light be allowed to fall on the mirror, the movement of the reflected ray of course increases in amplitude as the surface upon

which it is received is removed farther and farther from the mirrors, so that the characters described by it may be obtained of indefinite size. At the point where the size is as required, the reflected ray is made to impinge on a photographically sensitive strip of paper, and so gives a permanent record of its movements. The inventors realized that if the apparatus was to be of practical utility means must be found for the rapid development and fixing of the photographic image thus produced, and they were successful in devising an automatic machine which effects development in five or six seconds and fixing in six or seven seconds, the paper being then delivered almost completely dry, with only a slight dampness on the gelatine surface. Strips up to 25 meters long and 7 centimeters wide, containing 10,000 or 12,000 words, are successfully handled in this way. The speed of the telegraph as a whole is limited by the speed at which the perforations can be made—about 300 letters a second. But several perforating machines can be used to feed the transmitter proper, and that with the receiver can deal, it is said, with as many as 50,000 words an hour, though the number, of course, varies with the length and nature of the line in use. In some experiments made by the Hungarian postal department between Budapest and Pozsony, a distance of about 218 kilometers, with two copper telephone wires of 3 millimeters diameter, the transmission of 45,000 words an hour was found possible, while in another case between Berlin and Königsberg the maximum was about 40,000 words over a distance of 710 kilometers, with wires 4½ millimeters in diameter. The British Post Office, we understand, is about to carry out some trials with this extremely ingenious apparatus, which is the invention of two Hungarian electricians, Messrs. Antal Pollak and Jozsef Virag.

THE LIGHT OF THE STARS.*

By Prof. E. C. Pickering, Director of the Harvard College Observatory.

If an intelligent observer should see the stars for the first time, two of their properties would impress him as subjects for careful study; first, their relative positions, and secondly, their relative brightness. From the first of these has arisen the astronomy of position, or astrometry. This is sometimes called the old astronomy, since until within the last twenty years the astronomers of the world, with few exceptions, devoted their attention almost entirely to it. To the measure of the light should be added the study of the color of the stars (still in its infancy), and the study of their composition by means of the spectroscope. In this way a young giant has been reared, which has almost dwarfed its older brothers. The science of astrophysics, or the new astronomy, has thus been developed, which during the last few years has rejuvenated the science and given to it, by its brilliant discoveries, a public interest which could not otherwise have been awakened. The application to stellar astronomy of the daguerreotype in 1850, of the photograph in 1857, and of the dry plate in 1882, has opened new fields in almost every department of this science. In some, as in stellar spectroscopy, it has almost completely replaced visual observations.

One department of the new astronomy, the relative brightness of the stars, is as old as, or older than, the old astronomy. An astronomer even now might do useful work in this department without any instruments whatever. Hipparchus is known to have made a catalogue of the stars about 150 B. C. Ptolemy, in 138 A. D., issued that great work, the "Almagest," which for fourteen hundred years constituted the principal and almost sole authority in astronomy. It contained a catalogue of 1,028 stars, perhaps based on that of Hipparchus. Ptolemy used a scale of stellar magnitudes which has continued in use to the present day. He called the brightest stars in the sky, the first magnitude, the faintest visible to the naked eye, the sixth. More strictly, he used the first six letters of the Greek alphabet for this purpose. But he went a step further, and subdivided these classes. If a star seemed bright for its class, he added the letter μ (mu), standing for μειζων (meizon), large or bright; if the star was faint, he added ε (epsilon), standing for ελασσων (elasson), small or faint. These estimates were presumably carefully made, and if we had them now, they would be of the greatest value in determining the secular changes, if any, in the light of the stars. The earliest copy we have of the "Almagest" is No. 2389 of the collection in the Bibliothèque Nationale of Paris. It is a beautiful manuscript written in the uncial characters of the ninth century. A few years ago it could be seen by anyone in one of the show cases of the library. There are many later manuscripts and printed editions which have been compared by various students. The errors in these various copies are so numerous that there is an uncertainty in the position, magnitude, or identification of about two-thirds of the stars. A most important revision was made by the Persian astronomer, Abd-al-rahman al-sufi, who reobserved Ptolemy's stars, A. D. 964, and noted the cases in which he found a difference. The careful study and translation of this work from Arabic into French by Schjellerup has rendered it readily accessible to modern readers.

No important addition to our knowledge of the light of the stars was made until the time of Sir William Herschel, the greatest of modern observers. He found that when two stars were nearly equal, the difference could be estimated very accurately. He designated these intervals by points of punctuation, a period denoting equality, a comma a very small interval, and a dash a larger interval. In 1796 to 1799 he published, in the Philosophical Transactions, four catalogues, covering two-thirds of the portion of the sky visible in England. Nearly a century later, it was my good fortune, when visiting his grandson, to discover in the family library the two catalogues required to complete this work, and which had not been known to exist. These two catalogues are still unpublished. Meanwhile, little or no use had been made of the four published catalogues which, while comparing one star with another, furnished no means of reducing all to one system of magnitudes. The Harvard measures permitted me to do this for all six catalogues, and thus enabled me to publish magnitudes for 2,785 stars observed a century ago, with an accuracy nearly comparable with the best work of the present time. For nearly half a century no great advance was made, and no astronomer was wise enough to see how valuable a work he could do by merely repeating the observations of Herschel. Had this work been extended to the southern stars, and repeated every ten years, our knowledge of the constancy of the light of the stars would have been greatly increased. In 1844, Argelander proposed, in studying variable stars, to estimate small intervals modifying the method of Herschel by using numbers instead of points of punctuation, and thus developed the method known by his name. This is now the best method of determining the light of the stars, when only the naked eye or a telescope is available, and much valuable work might be done by applying it to the fainter stars, and especially to clusters.

Meanwhile photometric measures of the stars, according to various methods, had been undertaken. In 1856, Pogson showed that the scale of magnitudes of Ptolemy, which is still in use, could be nearly represented by assuming the unit to be the constant ratio, 2.512, whose logarithm is 0.4. This has been generally adopted as the basis of the standard photometric scale. The photometer devised by Zöllner has been more widely used than any other. In this instrument an artificial star is reduced any desired amount, by polarized light, until it appears to equal the real star, both being seen side by side in the telescope. Work with this instrument has attained its greatest perfection at the Potsdam Observatory, where measures of the light of the northern stars whose magnitude is 7.5 and brighter, have been in progress since 1886. The resulting magnitudes have been published for 12,046 stars, included in declination between —2 deg. and —60 deg. The accidental errors are extremely small, but as the results of different catalogues differ systematically from one another, we cannot be sure which is right and what is the real accuracy attained in each case. In 1885 the Uranometria Oxoniensis was published. It gives the magnitudes of 2,784 northern stars north of declination —10 deg. This work is a remarkable one, especially as its author, Prof. Pritchard, began his astronomical career at the age of sixty-three. The method he employed was reducing the light of the stars by means of a wedge of shade glass until they became invisible, and then determining the brightness from the position of the wedge. A careful and laborious investigation extending over many years has been carried on by Mr. H. M. Parkhurst, using a modification of this method.

For several years before the Oxford and Potsdam measures described above were undertaken, photometric observations were in progress at Harvard. In 1877 a large number of comparisons of adjacent stars were made with a polarizing photometer. Two images of each star were formed with a double image prism, and the relative brightness was varied by turning a Nicol prism until the ordinary image of one star appeared equal to the extraordinary image of the other. Several important sources of error were detected, which once known were easily eliminated. A bright star will greatly affect the apparent brightness of an adjacent faint one, the error often exceeding a magnitude. Systematic errors amounting to several tenths of a magnitude depend upon the relative positions of the images compared. They are perhaps due to the varying sensitiveness of the different parts of the retina. This photometer has many important advantages. However bad the images may be, they are always exactly alike, and may, therefore, be compared with accuracy. Both stars are affected equally by passing clouds, so that this photometer may be used whenever the stars are visible and at times when other photometric work is impossible. The diminution in light also follows a simple geometrical law, and is readily computed with great accuracy. There is no unknown constant to be determined, as in the Pritchard, and nearly all other photometers. The principal objections to this instrument are, first, that stars cannot be compared unless they are near together, and secondly, that faint stars can not be measured, since one-half of the light is lost by polarization. The principal uses so far made of this form of photometer are in comparing the components of double stars, and in a long series of observations of the eclipses of Jupiter's satellites, which now extends over a quarter of a century and includes 768 eclipses. Instead of observing the time of disappearance, a series of measurements is made, which gives a light curve for each eclipse. Much important work might yet be done with this form of photometer, in measuring the components of doubles and of clusters, and in determining the light curves of variables which have a moderately bright star near them.

An important improvement was made in this form of photometer in 1892 by which stars as much as half a degree apart could be compared. The cones of light of two such stars are brought together by achromatic prisms, so that they can be compared as in the preceding instrument. As there is no part of the sky in which a suitable comparison star can not be found within this distance, any star may be measured with this instrument. In the hands of Prof. Wendell, this photometer has given results of remarkable precision. The average deviation of the result of a set of sixteen settings is about three hundredths of a magnitude. Light curves of variables can therefore be determined with great precision, and suspected variables can be divided into those that are certainly variable, and those whose changes are probably less than a tenth of a magnitude.

Another change in this instrument produced the meridian photometer. Instead of using the two cones from one object glass, two object glasses were used, mirrors being placed in front of each. In this way stars however distant can be compared. In theory this instrument leaves but little to be desired. Almost every source of error that can be suggested can be eliminated by proper reversion. As constructed, the telescope is placed horizontally, pointing east or west. One mirror reflects a star near the pole into the field, the other a star upon the meridian. A slight motion of the mirror permits stars to be observed for several minutes before or after culmination. The first meridian photometer had objectives of only two inches aperture. With this instrument 94,476 measures were made of 4,260 stars during the years 1879 to 1882. All stars were included of the sixth magnitude and brighter, and north of declination —30 deg. The second instrument had objectives of four inches aperture, and permitted stars as faint as the tenth magnitude to be measured. With this instrument, during the years 1882 to 1888, 267,092 measures were made of 20,982 stars, including all the catalogue stars and all the stars of the ninth magnitude and brighter, in zones twenty minutes wide, and at intervals of five degrees, from the north pole to declination —20 deg. In 1889 the instrument was sent to South America, where 98,744 measures were made of 7,922 southern stars, extending the two preceding researches to the South Pole. On the return of the instrument to Cambridge 473,216 measures were made of 29,587 stars, including all those of the magnitude 7.5 and brighter north of declination —30 deg. This work occupied the years 1891 to 1898. The instrument was again sent to Peru in 1899, and 50,816 measures were made of 5,332 stars, including all those of the seventh magnitude and brighter, south of declination —30 deg. The latest research has been the measurement of a series of stars of about the fifth magnitude, one in each of a series of regions ten degrees square. Each of these stars is measured with the greatest care on ten nights. This work has been completed and published for stars north of declination —30 deg., 59,428 measures having been made of 839 stars. In this count, numerous other stars have been included. Similar measures are now in progress of the southern stars, this being the third time the meridian photometer has been sent to South America. The total number of measurements exceeds a million, and the number of stars is about sixty thousand. About sixty stars can be identified with care, and each measured four times with this instrument in an hour. The probable error of a set of four settings is ± 0.08.

The principal objection to the instrument just described is the great loss of light. To measure very faint stars, another type of photometer has been devised. A twelve-inch telescope has been mounted horizontally, like the meridian photometer, and an artificial star reflected into the field. The light of this star is reduced by a wedge of shade glass until it appears equal to the star to be measured. Four hundred thousand measures have been made with this instrument during the last five years. The principal research has been the measurement of all the stars in the Bonn Durchmusterung which are contained in zones ten minutes wide and at intervals of five degrees, from the north pole to declination —20 deg. Large numbers of stars of the tenth and eleventh magnitudes are thus furnished as standards of light. As the light of the object observed is unobstructed, any star, however faint, if visible in the telescope, may be measured. Accordingly, many stars of the twelfth and thirteenth magnitude have been selected and measured, thus furnishing faint standards. Sequences of standard stars have been selected from coarse clusters, thus permitting estimates or measures of these bodies to be reduced to a uniform photometic scale. An investigation of great value has been carried out successfully at the Georgetown College Observatory by the Rev. J. G. Hagen, S.J. All the stars of the thirteenth magnitude and brighter have been catalogued and charted in a series of regions, each one degree square, surrounding variable stars of long period. Besides measuring the positions he has determined the relative brightness of these stars. A sequence has then been selected from each of these regions, and measured at Harvard with the twelve-inch meridian photometer, thus permitting all to be reduced to a uniform scale. As the photometer was first constructed, stars brighter than the seventh magnitude could not be measured, since they were brighter than the artificial star and could not be rendered equal to it. This difficulty was remedied by inserting a series of shades, the densest of which

* An address at the International Congress of Arts and Science, St. Louis, September, 1904.

reduced the light by ten magnitudes. By this method, the range of the photometer may be increased indefinitely. Sirius and stars of the twelfth magnitude have been satisfactorily measured in succession. A further modification of the instrument permitted surfaces to be compared. The light of the sky at night and in the daytime, during twilight, at different distances from the moon, and different portions of the disk of the latter, have thus been compared. Measures extending over seventeen magnitudes, with an average deviation of about three hundredths of a magnitude, were obtained in this way. One light was thus compared with another six million times as bright as itself. A slight modification would permit the intrinsic brightness of the different portions of the sun's disk to be compared with that of the faintest nebulæ visible. By these instruments, the scale of photometric magnitudes has been carrried as far as the thirteenth magnitude. To provide standards for fainter stars, a small appropriation was made by the Rumford Committee of the American Academy. Co-operation was secured among the directors of the Yerkes, Lick, McCormick, Halsted and Harvard Observatories. Similar photometers were constructed for all, in which an artificial star was reduced any desired amount by a photographic wedge. Telescopes of 40, 36, 26, 23 and 15 inches aperture, including the two largest refractors in the world, were thus used in the same way on the same research. The standards have all been selected, and nearly all of the measurements have been made. This furnishes a striking illustration of the advantages of cooperation and combined organization. When these observations are reduced, we shall have standards of magnitude according to a uniform scale, for all stars from the brightest to the faintest visible in the largest telescopes at present in use. The sixty-inch reflector of the late A. A. Common has recently been secured by the Harvard Observatory. It is hoped that still fainter stars may be measured with this instrument.

We have as yet only considered the total light of a star, so far as it affects the eye. But this light consists of rays of many different wave lengths. In red stars, one color predominates, in blue, another. The true method is to compare the light of a given wave-length in different stars, and then to determine the relative intensity of the rays of different wave-lengths in different stars, or at least in stars whose spectra are of different types. This is the only true method, and fortunately spectrum photography permits it to be done. The Draper catalogue gives the class of spectrum of 10,351 stars, and the relative brightness of the light whose wave-length is 430, is determined for each. In 1891, measures were published of the relative light of rays of various wave-lengths, for a number of stars whose spectra were of the first, second, and third types.

A much simpler, but less satisfactory method, is to measure the total light in a photographic image. As in the case of eye photometry, this method is open to the objection that rays of different colors are combined. Blue stars will appear relatively brighter, and red stars relatively fainter, in the photograph than to the eye. This, however, is an advantage rather than an objection, since it appears to furnish the best practical measure of the color of the stars. Relative photographic magnitudes can be obtained in a variety of ways, and the real difficulty is to reduce them to an absolute scale of magnitudes. But for this, photographic might supersede photometric magnitudes. In other respects, photography possesses all the advantages for this work that it has for other purposes, and many photometric problems are within the reach of photography which seem hopeless by visual methods. In 1857, Prof. George P. Bond, the father of stellar photography, showed that the relative light of the stars could be determined from the diameter of their photographic images. This is the method that has been generally adopted elsewhere in determining photographic magnitudes, although with results that are far from satisfactory. It is singular that although this method originated at Harvard, it is almost the only one not in use here, while a great variety of other methods have been applied to many thousands of stars, during the last eighteen years. Relative measures are obtained very satisfactorily by applying the Herschel-Argelander method to photographic images, and if these could be reduced to absolute magnitudes, it would leave but little to be desired. In the attempt to determine absolute magnitudes a variety of methods has been employed. The simplest is to form a scale by photographing a series of images, using different exposures. The image of any star may be compared directly with such a scale. To avoid the uncertain correction due to the times of exposure, different apertures may be used instead of different exposures. Another method is to attach a small prism to the objective. The image of every bright star is then accompanied by a second image a few minutes of arc distant from it, and fainter by a constant amount, as five magnitudes. Trails may be measured more accurately than circular images, and trails of stars near the pole have varying velocities, which may then be compared with one another by means of a scale. Again, images out of focus may be compared with great accuracy and rapidity by means of a photographic wedge. These comparisons promise to furnish excellent magnitudes, if they can only be reduced to the photometric scale. A catalogue giving the photographic magnitudes of 1.131 stars within two degrees of the equator, and determined from their trails, was published in 1889. Great care was taken to eliminate errors due to right ascension, so that standards in remote portions of the sky are comparable. A similar work on polar stars at upper and lower culmination determined the photographic absorption of the atmosphere, which is nearly twice as great as the visual absorption. A catalogue of forty thousand stars of the tenth magnitude, one in each square degree, has been undertaken, and the measures are nearly complete for the portion of the sky extending from the equator to declination +30 deg. These stars are compared, by means of a scale, with the prismatic companions of adjacent bright stars. Two measures have been made of images out of focus of 8,489 stars, including all of those north of declination —20 deg., and brighter than the seventh magnitude. This work is being continued to the south pole. The most important completed catalogue of photographic magnitudes is the "Cape Photographic Durchmusterung," the monumental work of Gill and Kapteyn. 454,875 stars south of declination —19 deg. are included in this work. Unfortunately, the difficulty mentioned above, of reducing the magnitudes to an absolute system, has not been wholly overcome, but the work is published in a form which will permit this to be done later, if a method of reduction can be discovered. The extension of this great work to the north pole is one of the greatest needs of astronomy at the present time.

The map and catalogue of the Astrophotographic Congress, the most extensive research ever undertaken by astronomers, will not be discussed here, as it will doubtless be described by others better able than I to explain its merits. If completed, and if the difficulty of reducing the measures of brightness to a standard scale can be overcome, it will furnish the photographic magnitudes, as well as the positions, of two million stars. Time does not permit the consideration here of certain other investigations of photographic magnitudes, such as those made at Groningen. They generally relate to a comparatively small number of stars. The suggestion that the intensity of a photographic star image be measured by the amount of light it cuts off from a thermo-pile deserves careful study. It should give a great increase in precision, and would eliminate that tool of many defects, the human eye. No use seems to have been made so far of this method.

The next question to be considered is, what use should be made of these various measures of the light of the stars? The most obvious application of them is to variable stars. While the greater portion of the stars undergo no changes in light that are perceptible, several hundred have been found whose light changes. A natural classification seems to be that proposed by the writer in 1880. A few stars appear suddenly, and are called new stars, or novæ. They form class I. Class II. consists of stars which vary by a large amount during periods of several months. They are known as variable stars of long period. Class III. contains stars whose variations are small and irregular. Class IV. contains the variable stars of short period, and class V. the Algol variables, which are usually of full brightness but at regular intervals grow faint, owing to the interposition of a dark companion. Twenty years ago, when photography was first applied to the discovery of variable stars, only about two hundred and fifty of these objects were known. Since then, three remarkable discoveries have been made, by means of which their number has been greatly increased. The first was by Mrs. Fleming, who, in studying the photographs of the Henry Draper Memorial, found that the stars of the third type, in which the hydrogen lines are bright, are variables of long period. From this property she has discovered 128 new variables, and has also shown how they may be classified from their spectra. The differences between the first, second, and third types of spectra are not so great as those between the spectra of different variables of long period. The second discovery is that of Prof. Bailey, who found that certain globular clusters contain large numbers of variable stars of short period. He has discovered 509 new variables, 396 of them in four clusters. The third discovery, made by Prof. Wolf, of Heidelberg, that variables occur in large nebulæ, has led to his discovery of 65 variables. By similar work, Miss Leavitt has found 295 new variables. The total number of variable stars discovered by photography during the last fifteen years is probably five times the entire number found visually up to the present time. Hundreds of thousands of photometric measures will be required to determine the light curves, periods, and laws regulating the changes these objects undergo.

A far more comprehensive problem, and perhaps the greatest in astronomy, is that of the distribution of the stars, and the constitution of the stellar universe. No one can look at the heavens, and see such clusters as the Pleiades, Hyades and Coma Berenices, without being convinced that the distribution is not due to chance. This view is strengthened by the clusters and doubles seen in even a small telescope. We also see at once that the stars must be of different sizes, and that the faint stars are not necessarily the most distant. If the number of stars was infinite, and distributed according to the laws of chance throughout infinite and empty space, the background of the sky would be as bright as the surface of the sun. This is far from being the case. While we can thus draw general conclusions, but little definite information can be obtained, without accurate quantitative measures, and this is one of the greatest objects of stellar photometry. If we consider two spheres, with the sun as the common center, and one having ten times the radius of the other, the volume of the first will be one thousand times as great as that of the second. It will, therefore, contain a thousand times as many stars. But the most distant stars in the first sphere would be ten times as far off as those in the second sphere and accordingly if equally bright would appear to have only one hundredth part of the apparent brightness. Expressed in stellar magnitudes, they would be five magnitudes fainter. In reality, the total number of stars of the fifth magnitude and brighter is about 1,500; of the tenth magnitude, 373,000 instead of 1,500,000, as we should expect. An absorbing medium in space, which would dim the light of the more distant stars, is a possible explanation, but this hypothesis does not agree with the actual figures. An examination of the number of adjacent stars shows that it is far in excess of what would be expected if the stars were distributed by chance. Of the three thousand double stars in the "Mensuræ Micrometricæ," the number of stars optically double, or of those which happen to be in line, according to the theory of probabilities, is only about forty. This fact should be recognized in any conclusions regarding the motions of the fixed stars, based upon measures of their position with regard to adjacent bright stars.

We have here neglected all conclusions based upon the difference in composition of different stars. Photographs of their spectra furnish the material for studying this problem in detail. About half of the stars have spectra in which the broad hydrogen lines are the distinguishing feature. They are of the first type, and belong to class A of the classification of the Henry Draper Memorial. The Milky Way consists so completely of such stars that if they were removed it would not be visible. The Orion stars, forming class B, a subdivision of the first type in which the lines of helium are present, are still more markedly concentrated in the Milky Way. A large part of the other stars, forming one third of the whole, have spectra closely resembling that of the sun. They are of the second type, and form classes C and K. These stars are distributed nearly uniformly in all parts of the sky. Class M, the third type, follows the same law. Class F, whose spectrum is intermediate between classes A and C, follows the same law of distribution as classes G and K, but differs from them, if at all, in the opposite direction from class A. There, therefore, seem to be actually fewer of these stars in the Milky Way than outside of it. One class of stars, the fifth type, class O, has a very remarkable spectrum and distribution. A large part of the light is monochromatic. Of the ninety-six stars of this type so far discovered, twenty-one are in the Large Magellanic Cloud, one in the Small Magellanic Cloud, and the remainder follow the central line of the Milky Way so closely that the average distance from it is only two degrees. All of these stars, with the exception of sixteen, have been found by means of the Henry Draper Memorial.

It will be seen from the above discussion that stellar photometry in its broadest sense furnishes the means of attacking, and perhaps of solving, the greatest problem presented to the mind of man—the structure and constitution of the stellar universe, of which the solar system itself is but a minute and insignificant molecule.

LUMBERING IN FOREST RESERVES.

FEDERAL forest reserves are now fixed facts. It is a serious thing to withdraw from settlement, as the government has done, some 63,000,000 acres of land. But when the character of this land is understood, and the purposes the reservations will accomplish are known, it will be generally recognized that the area permanently reserved will serve the public best under forest cover. Its topography and soil unfit it for agriculture, but it is admirably suited to tree growth. Wisely administered, it will continuously furnish an immense timber output, while its influence in conserving the water supply for vast dependent agricultural areas will prove of inestimable value.

Without the establishment of reserves, proper control of the public forests is impossible. The present free use of timber is being greatly abused, and there is practically no management of these vast resources and no income from them, unless the timber and land are both sold outright and together. After the establishment of a reserve settlers within its boundaries and those living in its neighborhood are allowed, within definite and reasonable restrictions, free use of timber actually necessary for their domestic needs. The great change for the better, however, is that the reserve laws provide for the sale of timber in small or large quantities to persons both in and outside the reserve. Thus the forests can be made self-supporting, and through funds created in this way they can be protected from fire and be made more productive and useful.

But in making these sales the future of the forest is more considered than the money return from the timber cut. Hence the sales are strictly guarded by bonded contracts between the individuals and the government. The contracts specify the amount of timber bought and the price to be paid, limit the area and time of cutting, prescribe simple and practical regulations to guard against fire, and cover all essential relations between the contracting parties pending the completion of the contract. No trees can be cut except those previously marked by a government

official. Under such contracts millions of board feet of lumber are annually being cut from the reserves, to the improvement of their condition.

It is not the government's purpose to maintain the reserve forests untouched, but to use and develop them. Proper lumbering is as necessary to a productive forest as protection. Mature or ripe trees should be cut not only for the same reason that wheat or corn is, to save and utilize the product, but also to promote reproduction. Agricultural crops require sowing or planting each year, but forests, properly thinned by cutting, reproduce themselves and furnish a continuous crop. That this work may be effectively accomplished there must be protection from fires, and proper conditions for tree growth must be maintained. Important among these conditions is the demand of trees for room and sunlight. The young growth must be neither crowded nor shaded out. Thus, for the best results in reproduction the mature trees should be cut, and the dead and diseased timber should be disposed of as rapidly as possible.

Lumbering, however, as heretofore conducted, has had little concern for the effect of its operations on the forest. The immediate purpose was limited to getting out the valuable timber quickly, and little or no attention was given the damage to young growth, necessarily resulting from reckless tree cutting. Reserve management will stop reckless lumbering. The future welfare of the public forests depends on wise regulation of lumbering under such expert control as only the trained forester can exercise. This control must prevent injury to young growth from tree felling, must provide for thinning the forest so as best to assist reproduction, must where necessary resort to tree planting to rebuild the forest, and, most important of all, must prevent or quickly suppress all fires. None of these ends can be successfully attained while the forests remain public lands under no apparent control. Putting them under reserve is reclaiming them from an unguarded and unproductive state. It is the first step in putting them to their best use, through which lumbering and all industries depending on them will most permanently and largely thrive.

[Concluded from SUPPLEMENT No. 1516, page 24297.]

ON THE MODERN REFLECTING TELESCOPE, AND THE MAKING AND TESTING OF OPTICAL MIRRORS.*

By G. W. RITCHEY.

XVII. A MOUNTING FOR A LARGE REFLECTING TELESCOPE.

IN considering the requirements for a modern reflector mounting for photographic and spectroscopic work, the writer can probably not do better than to describe the designs for the proposed mounting of the 5-foot reflector. These designs are the result of experience both in optical work and in the use of the 2-foot reflector and the 40-inch refractor of the Yerkes observatory in astronomical photography.

With the present great improvements in the materials and methods of machine construction there is no longer any excuse for unstable and inconvenient mountings for reflectors. The focal length of modern reflectors intended for photography is short; the ratio of aperture to focal length generally used in such instruments will probably be not greater than as 1 to 4, nor less than as 1 to 6; with such ratios the mounting can be made extremely compact and rigid. By the addition of a small convex mirror the equivalent focal length can be increased from three and one-half to five times, and fine definition retained; when this is done the actual length of the tube is less than when the telescope is used at the primary focus.

The reflecting telescope defines well only at or near the optical axis; hence the mirrors must remain in perfect adjustment with reference to each other and to the eyepiece or photographic plate, in all positions of the telescope which can occur in use. Not only must the mirror supports be such as to define the position of the mirrors rigorously always, as described in the preceding chapter, but the short tube must be excessively strong and rigid so that no sensible flexure can occur. This is especially necessary when the telescope is used as a Cassegrain, or as a *coude;* for when these forms are employed it is only when the axes of the paraboloid and hyperboloid coincide that fine definition can be secured. When the necessity of these conditions is fully realized by makers and users of reflectors, a marked advance in the usefulness of reflecting telescopes will result. It was the lack of such rigidity and of such permanence of adjustments, fully as much as the lack of means of rigorously testing the optical surfaces, which made the old Cassegrain reflectors, including the great Melbourne instrument, such lamentable failures. I consider the failure of the Melbourne reflector to have been one of the greatest calamities in the history of instrumental astronomy; for by destroying confidence in the usefulness of great reflecting telescopes, it has hindered the development of this type of instrument, so wonderfully efficient in photographic and spectroscopic work, for nearly a third of a century.

When the telescope is to be used for photography, either direct or spectroscopic, it is indispensable that the mounting be so designed that reversal is not necessary when passing the meridian; for it is frequently necessary to expose for six or eight hours without reversal, on faint objects; and the best part of such an exposure is that in which the celestial object is near the meridian. Several forms of reflector mounting have been devised in which reversal is not necessary; the well-known English closed-fork mounting is one of them.

In designing the proposed mounting of the 5-foot reflector of the Yerkes Observatory, of twenty-five feet focal length, the writer has adopted the form in which a short open fork is used at the upper end of the polar axis. The tube hangs between the arms of this fork, being carried on two massive trunnions; the heavy lower end of the tube is so short that it can swing through, between the arms of the fork, for motion in declination.

The fork mounting presents several marked advantages with respect to compactness and stability, as well as convenience and economy, over all forms which are modifications of the German equatorial mounting, in which the tube is carried out at one side of the equatorial head. The tube, carrying the great weight of the mirror and its cell, is here supported at two opposite sides, instead of from one side only, as in the German forms; no heavy counterpoises are required; this form is much better adapted for the *coude* arrangement of mirrors, so essential in work with very large spectroscopes, only three reflections in all being necessary for this arrangement; furthermore, when the instrument is used at the primary focus, the upper end of the tube is more easily accessible, in all positions of the instrument, from an observing carriage attached to the inside of the dome.

The weight of the moving parts of the telescope will be about twenty tons. On account of this great weight, and also of the overhang of the fork above the bearings of the polar axis, an efficient anti-friction apparatus for the polar axis is demanded, which will at the same time relieve the effect of the overhanging weight of the upper end of the polar axis. The advantages afforded for this purpose by mercury flotation, when this is properly applied, are so great, and the mechanical details for such flotation work out so simply and economically, that this method will undoubtedly be used.

The proposed mounting will now be briefly described in detail, and attention will be called to many points which are indispensable to the success of a reflecting telescope to be used for photography.

The equatorial head consists of three iron castings, the triangular base-plate *m*, Plate IX, and the two posts *n* and *o*, which carry the bearings for the polar axis. Both posts are hollow, with walls 1¾ inch thick, and are bolted and pinned to the base casting; the post *n* contains the large driving clock.

The polas axis *p* is of hydraulic-forged steel, with a head or flange *q*, 48 inches in diameter and 7 inches thick, forged upon it; the axis is 14 1-3 feet long over all, is 20 inches in diameter for a distance of 2 feet below the head, and is 16 inches in diameter for the remaining 11 2-3 feet of its length; the axis is hollow, with walls 4½ inches thick. The bearings of the polar axis are of hard Babbitt metal, and are halved.

Attached to the lower surface of the 4-foot head of

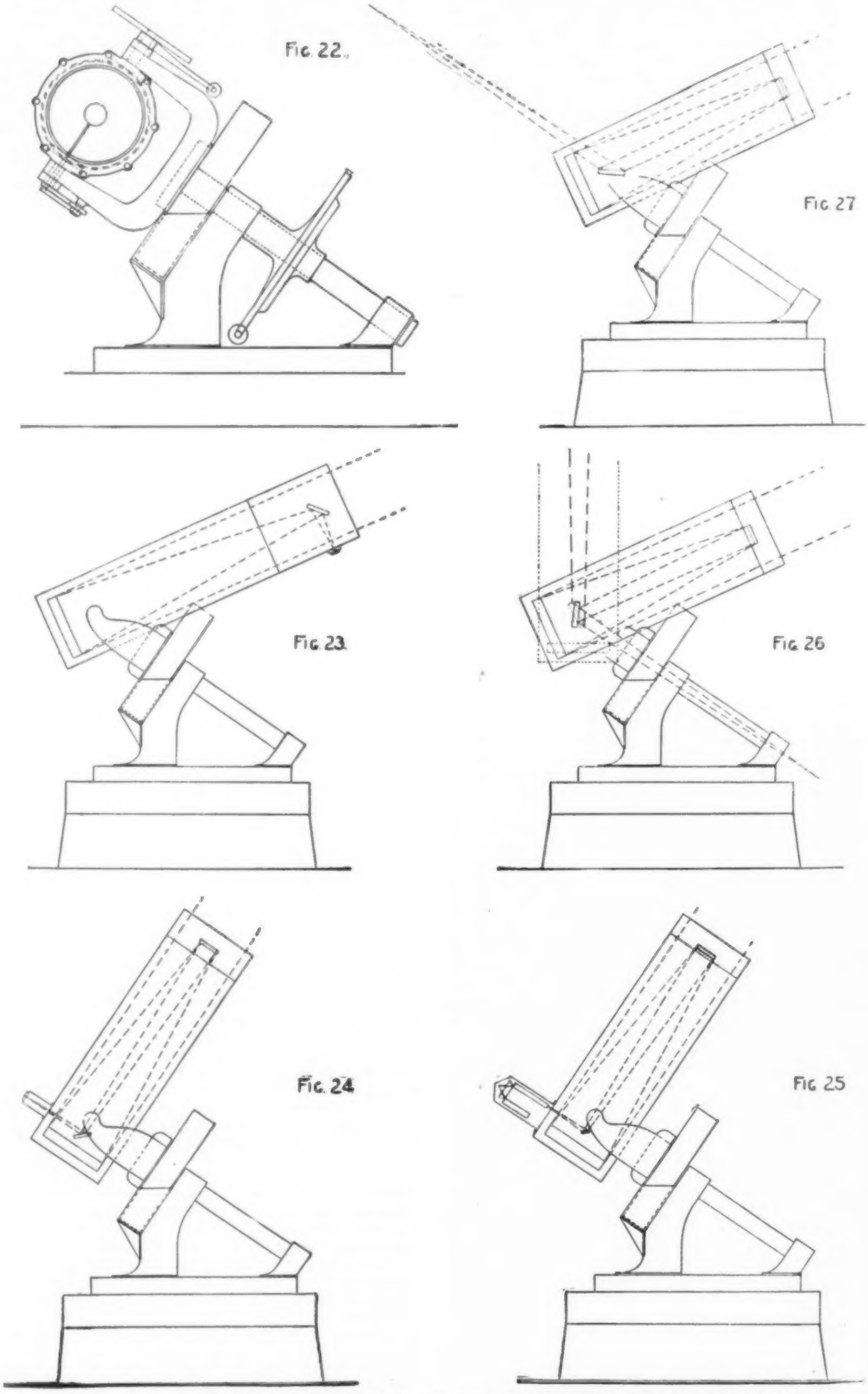


PLATE VIII.—DESIGN FOR MOUNTING OF FIVE-FOOT REFLECTING TELESCOPE.

* Reprinted from vol. xxxiv. Smithsonian Contributions to Knowledge.

the polar axis is the large hollow disk or float *r*, 10 feet in diameter and 22½ inches thick or deep; this is constructed very strongly of angle steel covered with steel plates ⅜ inch thick; the whole is finished smooth on the outside, and is turned true in a lathe. The corresponding trough *s* is of cast-iron and is turned true on the inside. The inner surface of the trough is separated by ⅛ inch all around from the outer surface of the float; this space is filled with mercury. With the dimensions given the immersed part of the float displaces about 45 cubic feet of mercury, which thus floats about nineteen tons, or 95 per cent of the weight of the moving parts of the telescope. The center of flotation is vertically below the center of weight of the moving parts. Only three-quarters of a cubic foot of mercury is required to float nineteen tons in this manner.

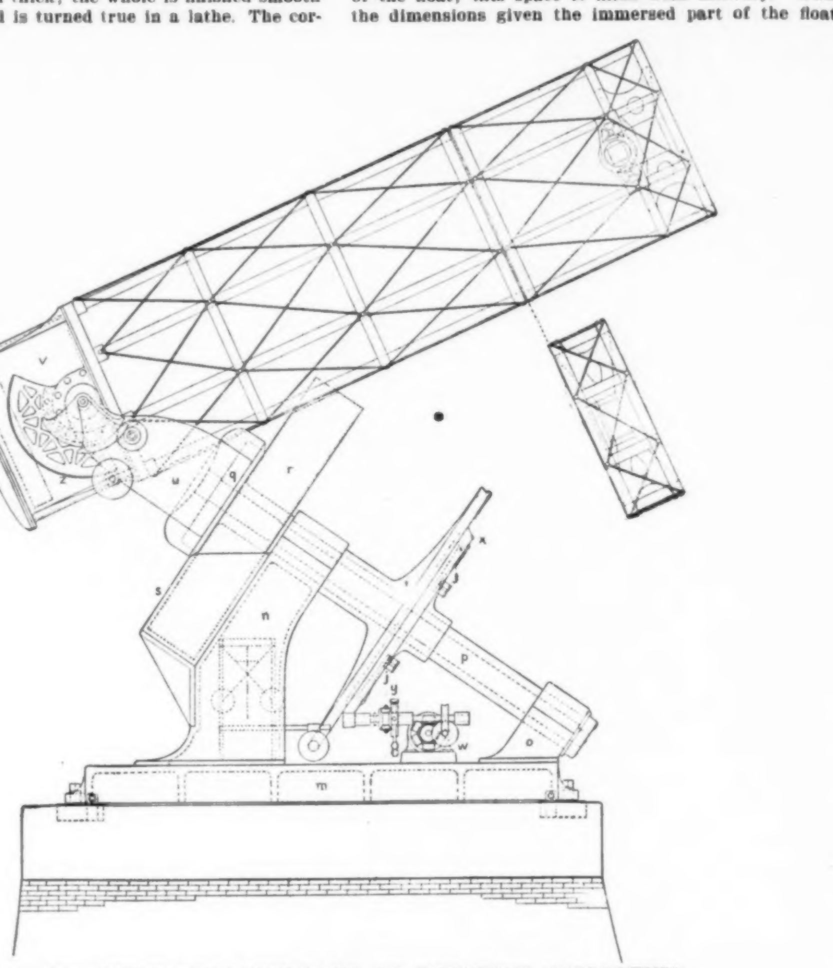


PLATE IX.—DESIGN FOR MOUNTING OF FIVE-FOOT REFLECTING TELESCOPE.

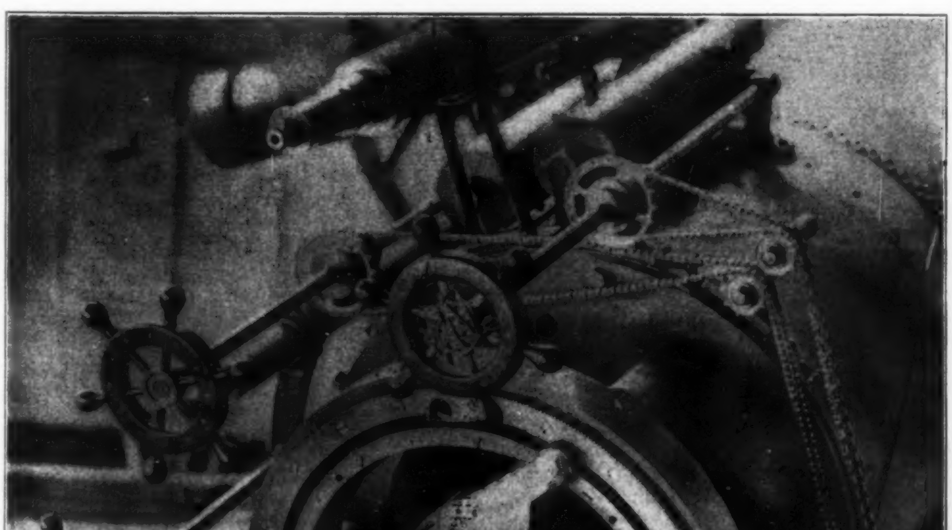


PLATE X.—LARGE DOUBLE-SLIDE PLATE-CARRIER ATTACHED TO 40-INCH REFRACTOR; YERKES OBSERVATORY.

The importance in astronomical photography of the smoothness of motion afforded by really efficient flotation of the moving parts cannot be overestimated. The great size of the worm-wheel *t*, which rotates the polar axis, will materially assist in giving smoothness and accuracy of driving; this worm-wheel is 10 feet in diameter.

Attached to the upper surface of the 4-foot head of the polar axis, by means of a circle of 2-inch bolts, is the large cast-iron fork *u*, different views of which are shown in Plate IX and Fig. 22, Plate VIII. The extreme outside width of this fork is 8 1-3 feet; it is of hollow or box section, with walls averaging 1½ inches thick; it weighs about five tons.

Between the two arms of the fork hangs the short round cast-iron section *v* of the tube; two 7-inch steel trunnions, having large heads or flanges, are bolted to this casting, and turn in bronze bearings at the upper ends of the fork arms; this part of the tube is 46 inches long; its inside diameter is 70 inches; its thickness is 1 inch; it is reinforced at top and bottom by flanges. To the lower flange is connected the cell-plate (described in the preceding chapter) which carries the large mirror and its support-system.

To the upper flange of the short cast-iron section of the tube is bolted a strong cast-iron ring which forms the lower end of the main or permanent section of the octagonal skeleton tube; this section is 13 feet 11 inches long, and 6 feet 8 inches outside (diagonal) diameter. It is constructed of eight 4-inch steel tubes, connected by strong rings designed to resist compression; diagonal braces, which are connected together at all intersections, greatly increase the rigidity of the structure. This entire section is so rigid that it can be placed in a large lathe for facing the ends parallel to each other, and for turning a slight recess in the ends for the purpose of accurately centering the parts which are to be connected to them.

To the upper end of the permanent section of the skeleton tube can be attached any one of three short extension tubes or frames, as desired; two of these are shown in Plate IX. The lower end of each extension is turned true, with a projecting ring which fits into the turned recess in the upper end of the permanent section. With this arrangement the various extensions can be removed and replaced without sensibly affecting the adjustments of the mirrors and other apparatus which they carry, with reference to the optical axis of the large mirror.

The extension which is shown in place on the telescope in Plate IX and in Fig. 23, Plate VIII, is the longest one; it is 6 feet 11 inches long; it is used for all work at the primary focus of the telescope; it carries the diagonal plane mirror and its supports, and the eyepiece and double-slide plate-carrier. This extension can be rotated upon the turned end of the permanent section, so that the eyepiece or photographic apparatus can be brought to the side of the tube which is most convenient for observing or photographing a given object. The diagonal plane mirror is of the finest optical glass, is elliptical in outline, is 15 x 22 inches in size, and is 3½ inches thick; it is carried in a strong cast-iron cell, which is supported from the skeleton tube by four thin steel plates, as shown in Plate IX. The diagonal plane mirror is sufficiently large to fully illuminate a field 7 inches in diameter at the primary focus. The double-slide plate-carrier is designed for 6½ x 8½-inch photographic plates.

The other two extensions of the tube, which are only about 2 feet long, are employed when the telescope is used as a Cassegrain and as a *coudé* respectively; each carries a convex mirror 19 inches in diameter and 3 1-6 inches thick, of the finest optical glass, and of the proper curvature for the purpose desired.

Figs. 24 and 25, Plate VIII, show the telescope used as a Cassegrain. In these cases the amount of amplification introduced by the convex mirror is about 3½ diameters; the equivalent focal length is therefore about 87½ feet, and the ratio of aperture to focal length as 1 to 17½. Fig. 24 shows the telescope as used for direct photography with the double-slide plate-carrier at the secondary focus. In Fig. 25 a spectrograph similar to the Bruce spectrograph of the Yerkes Observatory is shown attached to the north side of the short cast-iron section of the tube; this affords a most stable base of support for the spectrograph, at a point where it can be easily counterpoised.

Figs. 26 and 27, Plate VIII, illustrate the use of the telescope as a *coudé;* the curvature of the convex mirror is now such that the equivalent focal length is about 125 feet. The cone of rays from the convex mirror strikes a diagonal plane mirror at the intersection of the polar and declination axes, and is by it reflected *in a constant direction*, which can be toward either the north or south pole of the heavens, as desired. This arrangement is almost indispensable when extremely large and powerful spectroscopes and other kinds of physical apparatus are to be used with the telescope; the focus is now in a constant position, so that such instruments need not be attached to the telescope, but can be mounted on stationary piers, in constant temperature rooms, if desired.

A brief description of the mechanism for quick-motion and slow-motion in right ascension and declination should be given. These are planned to be entirely electrical, although hand-motions are added, to be used

in case of an emergency. Quick-motion in right ascension, both east and west, is given by the reversible motor w; this is connected by gearing to the large bevel-gear x through the medium of an electric clutch y. The bevel-gear x is permanently fixed to the polar axis. When the switch which starts the motor is thrown in, the electric clutch y acts, and a motion of rotation is communicated to the polar axis; this rotation is only at the rate of 45 degrees per minute; this is sufficient, since reversal is never necessary; hence very little power is required. The clutch is so adjusted that it will slip when even slight undue resistance is encountered. When the current is shut off from the motor the clutch is released automatically; the polar axis is then free from the motor and gear-train.

Quick motion in declination is given in a manner entirely similar to that in right ascension, by a small reversible motor attached directly to the large cast-iron fork; this motor drives, through the media of a gear-train and an electric clutch, the toothed sector z, which is permanently fixed to the cast-iron section of the tube.

The driving-clock and 10-foot worm-wheel are "clamped in" to the polar axis, when desired, by the electric clamps j which lock the 10-foot worm-wheel to the bevel-gear x; the former is of course free to turn on the polar axis when not thus clamped.

Slow-motion in right ascension is given by means of a small reversible motor which acts on a set of differential gears in the shafting connecting the driving-clock and the driving-worm. This device is used on the 2-foot reflector and on the 30-inch cœlostat, and is extremely simple and effective.

Slow-motion in declination is given by means of a small reversible motor which acts on the long sector attached to the upper trunnion shown in Fig. 22, Plate VIII.

In concluding this necessarily brief and incomplete description of a modern reflector mounting, attention should be called to an attachment which is absolutely indispensable for the best results in direct photography of all celestial objects requiring long exposure. I refer to the double-slide plate-carrier, by means of which hand-guiding or correcting for the incessant small irregular movements of the image, which are nearly always visible in large telescopes, can be done incomparably more accurately and quickly than by any other means now known. This device is due to Dr. Common, who described it in Monthly Notices, Vol. 49, p. 297. In 1900 the writer designed and constructed a small attachment of this kind for use with the 40-inch refractor and the 2-foot reflector; this attachment and its use are described in the Astrophysical Journal for December, 1900, p. 355.

A photograph of the central parts of the Andromeda Nebula was made by the writer with this small plate-carrier attached to the 2-foot reflector. The exposure time in this case was four hours. The images of the fainter stars on the original negative are only two seconds of arc in diameter; stars are shown which are more than a magnitude fainter than the faintest stars which can be detected visually with the 40-inch refractor; intricate structure and details are shown in the nebulosity, which are entirely invisible with the 40-inch refractor and all other visual instruments, and which have never been photographed before. When it is remembered that the focal length of the 2-foot reflector is only 93 inches, and that the aperture was in this case reduced to 18 inches, in order to secure a larger field than is well covered when the full aperture is used, some idea can be gained of the results which could now be obtained in celestial photography with a modern reflecting telescope which would compare in size, cost, and refinement of workmanship with the great modern refractors.

In Plate X is shown the large double-slide plate-carrier, taking 8 x 10 inch plates, which was constructed from the writer's designs in 1901, for use with the 40-inch refractor; the plate carrier is here shown connected to the eye-end of the great telescope. A description of this attachment, together with some photographs obtained with it, will be found in the "Publications of the Yerkes Observatory," Vol. II, p. 389.

CONTEMPORARY ELECTRICAL SCIENCE.*

EFFECT OF RADIUM RAYS ON METALLIC CONDUCTION.—J. Trowbridge and W. Rollins point out that, owing to the peculiar properties of radium rays, we are at last in a position to decide the question as to whether radiant energy exhibiting light and passing through a metal can affect the passage of a current of electricity, as it already does in a gas by ionization. They made the following experiment: A meter of aluminium wire was wound in five turns round a thick sheet of lead, which was 8 centimeters in length and 1 centimeter in width. The wire was wound round the longest dimension of this shuttle-like piece of metal, and was insulated from it by thin sheets of vulcanite. The electric current, therefore, passed in one direction along the upper layer of the wire, and in the opposite direction along the lower layer. The lead intervening between the upper and lower layer could serve to confine the radiations from suitably placed radium either to the upper or the lower layer of wire. The lead shuttle, with its layer of wire, was inclosed in a lead cylinder, and a specimen of pure radium bromide was inclosed at one end of the layers of wire, so that its enamations could sweep along the upper or the lower layer of this wire. A lead diaphragm could be used to shut off the entire effects of the radium from the wires. As a result, no instantaneous effect was observed; a very slight creeping deviation of the galvanometer mirror came after a considerable interval of time, which might have been due to change of temperature. It could not be ascribed with reason to the presence of radium. The light from the radium could be seen through a slab of iron 1 inch thick, yet this manifestation of energy passed through the aluminium without any apparent effect upon the mechanism of the electric current. The authors suggest that this negative result goes to support the theory that the mass of the electron is altogether apparent.—Trowbridge and Rollins, American Journal of Science, July, 1904.

THE ELECTRON THEORY.—W. Wien shows that the assumption that the electrons are not spheres, but Heaviside ellipsoids, not only satisfactorily explains Michelson and Morley's other experiment, but also supplements his own theory of radiation by electrons. According to Heaviside, the surface of an electric charge which is a sphere while at rest becomes in motion an ellipsoid whose axes are in the ratio

$$1 - \frac{v^2}{c^2} : 1 : 1,$$

where c is the velocity of light and v is the velocity of the electric charge. An electron will, therefore, only be a sphere when it is at rest. After being set in motion with respect to the ether it will assume a shape whose flatness increases with the velocity, and which becomes a circular disk when its velocity is that of light. This conception at once eliminates all the well-known difficulties of an electron moving with the velocity of light or a greater velocity, for the velocity of light is the greatest possible speed of the electron, since its shape becomes unstable as soon as that speed is exceeded. Another point of view newly introduced by this conception lies in a possible hysteresis between the velocity acquired by the electron and its corresponding change of shape. Such an hysteresis or retardation might have to be considered in an accurate theory of Röntgen rays. In any case, the new theory will bring us considerably nearer the reduction of mechanics to electro-magnetic principles.—W. Wien, Physikalische Zeitschrift, July 15, 1904.

QUASI RADIO-ACTIVITY PRODUCED BY POINT DISCHARGE.—Sella has shown that when a metallic body is connected to one terminal of an electrostatic machine, and made to face a series of points connected with the other terminal of the machine, and the discharge passed without sparking between them for, say, an hour, the body acquires an induced radio-activity if the discharge has taken place in fresh air, and not the air of a room closed for some time, while the presence near the body of thorium during the discharge greatly enhances this radio-activity. S. A. Edmonds has undertaken experiments to discover the origin of this activity. He fixed a series of disks made of aluminium, lead, copper, zinc, iron, and brass first to the terminal of a six-plate Wimshurst machine and then to a wire connected with an electrometer to measure the radio-activity. On the face of each disk after a discharge was seen a deposit which was darker at the places immediately opposite the points and very light at intermediate places. Tests made on this deposit showed the presence of slight traces of iron when needles were used as points, the "Prussian blue" precipitate being obtained, while, when other metals—copper, brass—were used, very faint traces of their presence were obtained from the various deposits produced by them. It was noticed that with slight deposits the activity was less than was the case with denser deposits, while, in one case, on accidentally wiping off the deposit, very little activity was found at all, which suggested that the deposit was in some way responsible for this radio-activity. These experiments show that this quasi radio-activity, produced by the action of the point discharge, is due to the presence of dust particles in the air. These dust particles come into contact with the stream of ions present, moving from the points to the plane carrying the discharge, and, when they become deposited on the plane, trap some of these ions, and hold them, so that they can only enter very slowly indeed into the metal of the disk under the force of attraction they experience by virtue of the charges carried by them. The disk thus has a film of ions held in the dust deposit on its surface, so that, if it be placed in the testing vessel and raised to the potential employed in the experiments, the electric field produced will act upon the ions thus trapped and increase their energy, thus enabling them either to go out from the disk and into the electrode facing it, thereby increasing the charge in the electrometer, or else to go into the metal of the disk, and so show no external effects.—S. A. Edmonds, Proceedings of the Cambridge Philosophical Society, August 19, 1904.

ANALOGIES BETWEEN RADIUM RAYS AND N-RAYS.—J. Becquerel has discovered some remarkable resemblances between the penetrating radium rays and N-rays on the one hand, and between the non-deflected "polonium" rays and the N'-rays on the other. These analogies appear in their respective behavior to a sulphide screen. Both the former make the screen emit secondary N-rays, which stimulate the visual faculty, while the latter reduce the visibility of a cross or patch of the sulphide. That the sulphide emits N-rays under the influence of the radiation from uranium salts may be shown by the following experiment: A cone of aluminium, such as is used for concentrating N-rays, is placed over some uranium salt. A sulphide screen placed at the apex then becomes slightly more visible, owing to the influence of the most penetrating rays. If now a little of the phosphorescent sulphide without being artificially excited, is brought near the uranium salt, the screen at the apex becomes much more distinct, owing to the N-rays emitted by the sulphide below. That the N-rays emitted are secondary is proved by the fact that the effect upon the eye is almost completely intercepted by distilled water, but not by salt water. The reverse effect was observed by means of a preparation of active bismuth containing polonium, and having an activity of 60. On bringing the polonium near a small luminous cross of calcium sulphide, the luminosity of the cross was considerably reduced. This was, however, only the case with the heavy α-rays of polonium. On stopping up the bottle containing the preparation and again exposing the screen near the wall of the bottle, it was found that the luminosity was increased, owing to the action of the penetrating β-rays, which are already known to increase the phosphorescence of a sulphide screen. The author dwells upon the great importance of the phosphorescent screen as a detector of radiations. It gives a reaction where photography fails to show anything, and where even the electroscope shows no effect. He suggests that the increase of luminosity may in many cases be due to β-rays hitherto undiscovered. He promises further analogies between N-rays and Becquerel rays.—J. Becquerel, Comptes Rendus, July 4, 1904.

RADIO-ACTIVITY AND LIFE.—J. J. Taudin Chabot makes some striking speculations on certain analogies shown by the phenomena of radio-activity with ebullition on the one hand and with the decompositions accompanying, say, the life of albumen, on the other. The atoms of radio-active substances are in a state of unstable equilibrium. Some of them, every now and then, pass abruptly into the next state. The passage amounts to an explosion, although it differs from ordinary explosions in not necessarily tending to the simultaneous explosion of all the other atoms around. A somewhat similar phenomenon is presented by a boiling liquid, where certain portions of the gasified liquid suddenly burst out from the interior, producing vortices in the liquid and taking portions away with them in the form of spray. The vortices would correspond to the γ-rays, the gas and the spray to the β-rays and α-rays respectively. Some striking analogies to the behavior of the emanations and the rare gases such as argon and helium are offered by nitrogen, which is a constituent of nearly every explosive substance. Among the compounds of nitrogen, cyanogen, CN, deserves special consideration on account of its importance in the decomposition of albumen. All the nitrogenous compounds resulting from the decomposition of albumen contain cyanogen. This has a high internal energy and is therefore extremely unstable. Pflüger believes it to be a constituent of all living matter, and calls cyanic acid a "semi-living" molecule. The presence of oxygen increases the instability of the cyanogen compounds, so that, as in the case of the emanations, the least impulse suffices to make the living molecule "explode" and produce carbonic acid, as radium produces helium. The transformation of albumen under the influence of oxygen takes place according to an exponential law, as does the decay of radio-activity. Like the radio-active substances, albumen has a limited and predetermined life. The phenomena of life would thus become in principle identical with those of radio-activity, and an equally necessary result of known causes, but of a much wider scope in nature.—J. J. Taudin Chabot, Physikalische Zeitschrift, October 1, 1904.

EFFECT OF SCREENING ON IONIZATION.—A. Wood has made an attempt to discover the causes of the so-called spontaneous ionization of the gas contained in a closed vessel. Wilson and Strutt ascribe it to a primary radiation of the material of the walls, whereas McLennan and Rutherford and Cooke have shown that the ionization is also to some extent due to a very penetrating radiation from without which passes through the walls of the vessels. The author argues that if the latter is the chief agency at work, it must be possible to intercept it entirely or partly by screen. He therefore surrounded vessels of lead, tin, iron, aluminium, and zinc with a lead screen, 1.3 centimeters thick, and noted the reduction of spontaneous ionization thus produced. It amounted to 23 per cent in tin, iron, and zinc, and to about half that in lead and aluminium. When an iron screen was substituted for the lead screen, the proportionate reduction remained about the same, except that tin ranged itself among the metals which are less subject to the screening effect. The author concludes that a considerable part of the spontaneous ionization, being unaffected by the screening, is produced by a radiation from the walls. This "intrinsic" radiation is great in lead and aluminium and small in iron, zinc, and tin.—A. Wood, Proceedings of the Cambridge Philosophical Society, 12, Part 6, 1904.

EVOLUTION OF METALLIC STRUCTURE.—G. Cartaud reports having found traces of a cellular structure in the soft metals lead, tin, and zinc, which he has succeeded in polishing and etching. Lead, which is the most difficult to polish, also presents the most decisive evidence of cellular structure. When attacked by picric acid dissolved in acetone it shows a completely closed microscopic network of cells. There is, however, evidence to show that this network is shown up by a kind of development, and is but the relic of an actual structure in what might be called the embryonic stage. Apart from this small cellular network, there is a much larger crystalline network which indicates

* Compiled by E. E. Fournier d'Albe in the Electrician.

the final stage of the solidification. The lines of this network are straight and freely intersect the waving lines of the cellular network. The author compares them to lines drawn along the course of a river, but so as to indicate the general or average course. The crystallization follows the original or embryonic lines, but rectifies them. When an ingot is deformed and then annealed the relation between the crystalline and the cellular networks disappears.—G. Cartaud, Comptes Rendus, August 16, 1904.

TRADE NOTES AND RECIPES.

Silver Polish.—

Alum	2 ounces
Precipitated chalk	4 ounces
Bitartrate potassii	4 ounces

Water, q. s. to make a paste.—Fundgrube.

To Clean Sponges.—Rinse first well in very weak warm caustic soda lye, then with clean water, and finally leave the sponges in solution of bromide in water till clean. They will whiten sooner if exposed to the sun in the bromine water. Then repeat the rinsings in weak lye and clean water, using the latter till all smell of bromine has disappeared. Dry as quickly as possible, and in the sun if it can be done.—Augsburg Seifensieder Zeitung.

To Fix Metal to Wood Without Nails.—In order to fasten metal to wood without the use of nails or screws, the metal parts are roughened by the use of dilute sulphuric acid. As soon as the metal has been wiped dry, it is glued on with the best joiner's glue to which a little glycerine has been added. This process is not only adapted for small plates or slabs, but also larger ones, but care must be taken that they touch the finely roughened wood surface evenly throughout. —Neueste Erfindungen.

Production of French Harness Dressing.—A French harness dressing of good quality consists of oil of turpentine 900 parts, yellow wax 90 parts, Berlin blue 10 parts, indigo 5 parts, and bone black 50 parts. Dissolve the yellow wax in the oil of turpentine with the aid of moderate heat in a water bath, mix the remaining substances, which should previously be well pulverized, and work them with a small portion of the wax solution. Finally, add the rest of the wax solution, and mix the whole well in the water bath. When a homogeneous liquid has resulted, pour it into earthen receptacles.—Neueste Erfindungen.

Removing Paint and Varnish from Wood.—The following compound is given as one which will clean paint or varnish from wood or stone without injuring the material:

	Pounds or ounces.
Flour or wood pulp	385
Hydrochloric acid	450
Bleaching powder	160
Turpentine	5

This mixture is applied to the surface and left on for some time. It is then brushed off, and brings the paint away with it. It keeps moist quite long enough for it to be easily removed after it has acted.—Revue des Produits Chimiques.

Paper Barometers, or more correctly indicators of humidity, are produced as follows:

Soak blotting paper with a solution of—

Cobalt chloride	30.0
Sodium chloride	15.0
Gum arabic	7.5
Calcium chloride	4.5
In water	45.0

and dry.

The various colors of the paper indicate the degree of moisture contained in the atmosphere, viz.: Rose color, rain; pale red, very humid; bluish red, humid; lavender blue, almost dry; blue, very dry.—Neueste Erfindungen.

Carbolineum.—This is a liquid intended to preserve wood from mold and dry rot. It is so effectual that numerous worthless imitations under the same name are upon the market, so that it is of importance to know how to make the real article, one which will destroy the albuminous matter of the wood and the organisms which feed on it, so there are neither germs nor food for them if there were any. The specific gravity of a carbolineum should exceed 1.105, and should give the wood a fine brown color. It should, too, be perfectly waterproof. The three following recipes can be absolutely relied on: 1. Heat together and mix thoroughly 95 pounds of coal-tar oil and 5 pounds of asphalt from coal tar. 2. Amalgamate together 30 pounds of heavy coal-tar oil, 60 pounds of crude wood-tar oil, and 25 pounds of heavy rosin oil. 3. Mix thoroughly 3 pounds of asphalt, 25 pounds of heavy coal-tar oil, and 40 pounds of heavy rosin oil.—Wiener Seifensieder Zeitung.

Elastic Glue.—Although elastic glue is less durable than rubber, and will not stand much heat, yet it is cheaper than rubber, and is not like rubber affected by oil colors. Hence it is largely used for printing rollers and stamps. For stamps, good glue is soaked for 24 hours in soft water. The water is poured off, and the swollen glue is melted and mixed with glycerine and a little salicylic acid, and cast into molds. The durability is increased by painting the mass with a solution of tannin, or better, of bichromate of potash. Printing rollers require greater firmness and elasticity. The mass for them once consisted solely of glue and vinegar, and their manufacture was very difficult. The use of glycerine has remedied this, and gives great elasticity without stickiness, and has removed the liability to get moldy. Swollen glue, which has been superficially dried, is fused with glycerine and cast into oil molds. Similar mixtures are used for casting plaster ornaments, etc., and give very sharp casts. A mass consisting of glue and glycerine is poured over the model in a box. When the mold is removed, it is painted with plaster outside and with boiled oil inside, and can then be used many times for making reproductions of the model.—Farben Zeitung.

Glue Testing.—Dr. Kissling is of the opinion that the usual methods, viz., either throwing down the gluten with tannin or direct determination of the nitrogen present, affords no accurate test of the value of a glue. He recommends taking the fusion point of the jelly made by soaking the glue in water. He states that as regards adhesive power, cheap bone glue is the equal of the best leather glue, but for lining casks leather glue is better, as the jelly is much firmer. The solidity of the jelly depends upon the method of manufacture, and the more of the gluten is changed into glucose during the processes, the less solid is the jelly. The durability of a glue may be judged by its smell, and leather glues are more durable than bone glues, having less smell. The amount of free and combined sulphurous acid present is often very important, and leather glues are better in this respect than bone glues. The determination of water, fat, or ash is of little value. Of late the manufacture of bone glue has been greatly improved, and good bone glue is the equal of medium leather glue in every respect. Kissling says that solidity of the jelly and freedom from acid and from smell are the tests of a good glue. Mixed glues are to be avoided, for they combine the price of leather glues with the nature of bone glues.—Farben Zeitung.

ENGINEERING NOTES.

At seven o'clock on the evening of November 25, says the Electrical Review, the New York subway had completed twenty-nine days of operation. In that time 5,838,235 passengers were carried, not counting policemen and firemen, who travel free, or the people who travel on passes. These figures do not include the traffic of the Lenox Avenue branch, which had been running for a few days before that time. A trifle over one-fifth of the passengers entered the trains at the Brooklyn Bridge, the total number of passengers from this station being 1,185,863. The Fourteenth Street station contributed 428,318, and the Grand Central station 476,670. The average daily traffic, not including the Lenox Avenue branch, was 201,318. The daily average receipts were $10,065.90.

A steam roller is better property for a town to own than a stone crusher, for both are purchased at the expense of the town, and the stone crusher can only be used to crush a small portion of stone each year for a main highway or a favored district, and the balance of the time is idle, while a steam roller can be used on every mile of highway through the entire town, to take out the ruts and make the roadway solid after turnpiking and grading has been done (or after heavy storms) and the hard surface left by the steam roller permits the water falling on the surface of the road to run rapidly to the ditches. After a thorough system of drainage has been established along the highways, then is the time to use the stone crusher and place the crushed stone upon the road, because then it will not be wasted, but will give the continuous hard surface that it is expected to give. Stone, placed upon an undrained road, sinks out of sight in the mud. Many a highway commissioner has only learned this after spending hundreds of dollars of the taxpayers' money.

The damming of the River Thames at London is being considered by a royal commission. As there is a difference between high and low tide of 18 or 20 feet, all larger vessels must be handled in docks which can be closed by tidal gates. The object of the commission is to devise means for doing away with this inconvenience, and thus increasing the shipping facilities of the port. Among the plans presented is one for constructing a great dam across the Thames from Gravesend to Tilbury. This would convert the river into a great inland lake, extending from Gravesend to Richmond. At the point selected for the dam the river bed is of fine chalk, and the structure would give a navigable depth of 65 feet at Gravesend and 13 feet at London Bridge, without any dredging. The proposed dam would be made of concrete, granite-faced. The four locks would be 300, 500, 700 and 1,000 feet long and from 80 to 100 feet wide. The estimated cost is $18,-290,000. As all the docks could be left open, there would be an annual saving of $250,000 in the cost of operating the gates.—Iron Age.

Prof. C. Bach has presented in the Zeitschrift des Vereines Deutscher Ingenieure the results of an elaborate series of tests of the strength of steel at high temperatures. Bars from three different works were tested, these being distinguished by the letters *O*, *K*, and *M*. Of the bars *O*, four were subjected to tensile tests at ordinary temperatures, and successive lots of four to tests at the temperatures 200, 300, 400, 500 and 550 deg. C. At ordinary temperatures the strength of the steel was for bar No. 2, for example, 27 tons per square inch, the ultimate extension on a gage length of 8 inches 26.3 per cent and contraction of area 46.9 per cent. The results of the tests showed that the strength increased up to 300 deg. C. by about 3.17 tons per square inch, and from this temperature onward the strength fell, roughly in proportion to the temperature, to 13.1 tons per square inch at 550 deg. C. The ultimate extension decreased from 25.5 per cent at ordinary temperatures to 7.7 per cent at 200 deg. C., from which again it rose to 39.5 per cent at 550 deg. C. The contraction of area also fell at 200 deg. C., but did not commence to rise until the temperature was above 300 deg. C. In the case of the bars from the works distinguished by the letters *K* and *M*, tests were made by keeping the loads on for a considerable time. This prolonging of the action of the load had no effect until the temperature reached 300 deg. C., at which point it caused a slight decrease of strength, and at 400 and 500 deg. a greater decrease. As regards the effect of prolonged loading on the extension and contraction between the temperatures of 300 and 400 deg. C. it caused an increase in both, but from 400 deg. C. the extension and contraction under prolonged loading decreased until at 500 deg. C. they were lower by from 20 to 25 per cent than with ordinary duration of test. Prof. Bach draws the conclusion from his investigations that for steam boilers, piping, etc., the strength of steel should be tested at the higher temperatures; and he is of opinion that this conclusion is justified not only by his experiments, but from the well-known fact of the brittleness of steel when worked at a blue heat.

ELECTRICAL NOTES.

America leads in the utilization of electric power for the driving of textile mills. In a recent paper by Mr. Charles Robbins, the author points out that in 1900 there was being used approximately 800,000 horse-power in 98½ per cent of the American cotton mills, while there are now electric motors aggregating 140,-000 horse-power in use. No doubt the antipathy on the part of British textile manufacturers to adopt this system has been due to the high charges for electrical energy. One manufacturer informed us recently that to compare with an up-to-date steam plant electricity would have to be supplied at one halfpenny per unit. The charges ruling at the present time range from one penny upward per unit, so that it would appear that on the score of cost there is very little inducement to adopt electric driving. On the other hand, it is claimed for electricity that the mills turn out more work, and of a better quality, than those driven by mechanical means.

The Damping of Condenser Circuits, Including a Spark Gap.—In a paper published in the Annalen der Physik, Prof. P. Drude states that for each condenser circuit, including a spark gap, there is a certain range of spark lengths, giving a minimal damping effect. Within this range of spark lengths, the decrement depends on the spark length hardly to any appreciable degree, being reduced to a value approximately identical with any oscillation circuits (with very different capacities and self-inductions) provided the sparks be fed from an induction coil at the proper intensity, and the condenser be devoid of any hysteresis or brush discharge. The most suitable exciting condensers fulfilling these conditions are metal plates in petroleum or other suitable oils, any direct connection of the oppositely-charged metal plate by solid insulators being avoided. Zinc electrodes show the smallest damping decrement, even after prolonged use without cleaning. Shortly after the cleaning, the activity of the sparks is increased to some degree. The integral effect of the exciting circuit in a resonance circuit is found first to increase and then to decrease with augmenting spark lengths, being enforced somewhat by intense feeding of the spark. The spark resistance as calculated from the decrement depends only to a very limited degree on the spark length, but to a very high extent on the capacity and self-induction of the circuit, decreasing with increasing figures.

The most recent progress in the use of electricity on war vessels is represented by the electrical equipment which has been installed on board the battleship "Brunswick." This vessel is one of the most powerful units of the German war fleet. It has a displacement of over 14,000 tons and makes a speed of 18 knots with its engines of 16,500 horse-power. Its artillery is composed of 4 rapid-firing guns of 28 centimeters (11.2 inches), 12 of 8 centimeters (3.2 inches), 12 of 8.8 centimeters (3.5 inches), and 12 of 3.7 centimeters (1.1 inches), without counting 8 revolving guns and 6 torpedo tubes. The lighting of the whole ship is carried out by means of 1,100 incandescent lamps. The vessel has four great projectors, each one giving sixty-one million candle power, with glass reflectors of 36 inches diameter. Two of these projectors are lodged in the rigging. The two others, which are placed on the sides of the vessel, are protected by an armored casing when not in use. The seventeen main electric ventilating fans in different parts of the ship take 65 horse-power, and 250 horse-power are needed for the motors which operate the fourteen hoists for ammunition and auxiliary apparatus for the artillery, with the four coal elevators and the two large cranes for the boats. There are fifty-six electric motors of 520 horse-power total, for the repair shops, the ice-machines, and cooling apparatus, the water pump for baths, etc. Independent of the main fans there are a great number of small fans for the cabins and saloons. The signaling apparatus, furnished by Siemens & Halske, extends to all the maneuvers which are carried out on board. A complete wireless telegraphy post on the "Telefunken" system is installed. Current for the entire vessel is supplied from two dynamo rooms on board. Each of them contains a steam dynamo of 125 horse-power and a second of 90 horse-power. The lamps and signals which are indispensable in case of combat are connected so that they can be supplied from a large battery of accumulators.

SCIENCE NOTES.

At a recent meeting of the Institut Genevois (December 13) Dr. Th. Tommasina offered an interesting communication in connection with the "pyro-radioactivity," that is, the radioactivity taken by heated bodies which he discovered. In the course of some theoretical and philosophical considerations, Dr. Tommasina points out the relation existing between the radioactivity shown by bodies and the imperceptible links of the corpuscular elements constituting the body. While being apparently inert, a body is in reality the synthesis of the individual motions of these invisible particles, its immobility being only a seeming one, and resulting from the state of equilibrium that may arise between the never-ceasing movements of the particles of the body and those of the surrounding medium. The inertia of bodies is accordingly nothing else than a state of restraint maintained by mechanical links. Radioactivity would then be the discontinuance of equilibrium between these links; and as from recent discoveries it would seem as though these links were of an electrical character, the inertia of bodies would also be an electrical phenomenon. The high bearing of this conclusion, allowing as it does of a novel theory of the constitution of matter, is self-evident. Dr. Tommasina next describes the apparatus, experimental arrangements, and methods used by himself for investigating the normal radioactivity of bodies, as well as their temporary radioactivity, assumed on being heated ("pyro-radioactivity") and which in turn gives rise to an induced or secondary activity.

The author thinks that by means of radioactivity we are likely eventually to discover the nature of chemical affinities as well as the origin of life, in virtue of an investigation of the radioactivity, characteristic of living organisms, which Dr. Tommasina recently discovered with animals and plants.

Messrs. Delage and Legatu, of Paris, have obtained some interesting results by applying the microscopic method of research to the study of arable earth. They give the following account of their researches in a paper presented to the Académie des Sciences. Up to the present the analytical study of arable earth has been based first upon the mechanical separation of portions of more or less fine fragments by means of washings and siftings, or again by chemical separation which allows us to determine the proportions of calcareous, silicious, organic portions and the quantities of certain elements known as fertilizers. A finer analysis than this would be of great value to agronomy as it would furnish a complete list of the mineral species which enter into the composition of a given earth. Our researches which have been carried on for a year past have given a number of interesting results. We will only consider at present those which bear upon the alimentary conditions of arable earth as regards plant growth. Our method of observation consists essentially in preparing a thin layer of the fine part of the earth with parallel surfaces and in examining this thin layer under the polarizing microscope and by parallel rays, after the manner of rock specimens. The arable earth which is presented in the classic treatises as the result of a disaggregation and a decomposition of the essential minerals of rocks, is shown to us in a very conclusive manner as the simple product of disaggregation. The minerals are in fact in the state in which they are found in the original rocks. For instance, the feldspar is normal, as also the quartz; we find the micas, calcite, tourmaline, apatite, etc., in the same condition. They have not undergone decomposition nor localized corrosion. Seeing that the arable earth is thus to be likened to a rock simply reduced to powder, we are naturally brought to ask how the plants can live in it. Only one hypothesis seems to accord with our observations. It consists in admitting that all the chemical transformations of which the arable earth is the seat are the result of simple and direct solutions of its mineral constituents, which yield to different solvents, water for instance, in a very small but constant proportion, and thus give up the whole of their substance. We thus find that feldspar, mica, apatite, talc, calcite, dolomite, etc., are dissolved and these solutions, which leave the undissolved part of the minerals intact, are the preparatory and necessary act for the succeeding chemical reactions. This conclusion, which is to some extent made necessary by the state of the minerals in the arable earth, is in accord with what we know as to the solubility of finely pulverized minerals (referring especially to M. Menier's experiments) and as to the composition of potable waters. It accords remarkably with the recent conclusive experiments of Schloesing which liken assimilable substances to those which are dissolved in water. Outside of this general conception of arable earth, the microscopic observation in thin layers furnishes many data, as will be understood. It shows us quickly the great majority of elements which make up such earth. It reveals the natural combinations, that is, the minerals in which these elements are engaged, and once the species are given, we have then their characteristics and properties. The number of elements thus brought out is very often greater than that which chemical analysis shows us, since the latter only seeks what seems to be of special interest. The new method shows the origin of the minerals of the earth and the nature of the primitive eruptive or sedimentary rocks which furnished them. Lastly it affords such an important aid to agronomical study that henceforth it seems that all thorough researches upon arable earth should use the chemical and mineralogical analyses together, as these will complete and elucidate each other in a very satisfactory way.

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